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Concrete

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Co-ordination of Basic Principles of Concrete Mixtures

First Article of Series Explains Importance of Absolute Volume—Erroneous Results from Bulk and Weight Measures—Feret Law of Mixtures

I—Absolute Volume, the Basic Measure of Ingredients

By JOSEPH A. KITTS
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TECHNOLOGICAL control of concrete production at commercial plants requires routine testing of materials and reproportioning of ingredients as aggregates vary in quality, maximum size, density, specific gravity, fineness modulus, moisture content, absorption, etc. It requires evaluation of cement qualities. It requires a more complete and efficient system of material tests and mixture formulation than has been available in any one individual's theory of concrete making. It demands a co-ordination of available knowledge of the physics of concrete mixtures. The co-ordination to be presented in subsequent paragraphs is the first step in this direction.

Scope of Articles

This article and others to come will comprehend the following developments in concrete physics and technology:

(1) The use, practically as well as technically, of absolute volume as the basic measure of proportions (the most fundamental principle of mixture formulation);

(2) The physico-mathematics of measurement of absolute volumes of materials by weighing, by loose-moist, loose-dry, or dry-rodded volume, or by inundation;

(3) A co-ordinated, systematized field and laboratory procedure of pretesting materials and concretes, and of concrete research;

(4) The law of the optimum cement content for any maximum size of aggregate, strength and slump;

(5) The law of the optimum slump for any maximum size of aggregate;

(6) The Abrams water-cement ratio law for any strength, and its application;

(7) Elaboration of the Feret law of yield of combinations;

(8) Elaboration of the Fuller and the Talbot-Richart grading equations for aggregate mixtures;

(9) Co-ordination of the Abrams fineness modulus principle, the Kitts law of the optimum fineness modulus, and the Talbot-Richart grading equation, providing an accurate and expedient algebraic method of determining proportions, of three, four, five or more size separations

This series of articles will present a co-ordination of the various basic principles of mixtures advanced by Thacher, Feret, Fuller, Talbot, Abrams, the author and other workers in concrete research, a development made by the author in connection with technological control of production at commercial concrete mixing plants.

The concrete technologist for the commercial concrete plant must expediently and accurately proportion concretes of any practicable combinations of maximum size of aggregate, strength and slump; also, in any arbitrary proportions, cement contents, water-cement ratios, filler to voids ratios, gradings, fineness moduli, and other practicable requirements of the buyer of concrete. His volumes of concrete delivered must be predetermined within one-half of one per cent. Proportioning control of quality concrete must be done with a high degree of technical skill and efficiency as an essential of successful manufacture.—The Author.

of aggregates, for grading uniformly to a given fineness modulus;

(10) Appreciation of the voids and density theories of proportioning;

(11) Elaboration of the Thacher law of the sand-cement ratio for any strength;

(12) Development of the physico-mathematics of materials and mixtures, empirical equations, and a complete and simple calculation method of mixture formulation for given characteristics of materials; and

(13) Co-ordination of these laws and developments for practical use in preliminary, routine and research tests, and for technological control of production.

Related Laws of Mixtures

This co-ordination supplies the following related laws of mixtures, providing a complete calculation method of mixture formulation and comprehending all the established fundamental physics of mixtures:

(1) Law of the optimum cement content for any maximum size of aggregate and strength and slump of concrete;

(2) Law of the water-cement ratio for any strength;

(3) Law of the aggregate content;

(4) Law of the optimum fineness modulus for the given cement content and maximum size of aggregate;

(5) The grading equation for the given fineness modulus and maximum size of aggregate; and

(6) The law of yield of combinations of ingredients.

Basic Measure of Ingredients

The practical application of this development has been presented in the November and December, 1931, issues of Concrete under the title "Co-ordinated Laws of Concrete Mixtures and Their Application." The methods of determination of the physical characteristics of aggregates, and of calculation of mixtures, of any maximum size of aggregate, and strength and slump of concrete, are simple and fundamental and readily acquired by the technical student. However, the derivations of the various laws and their empirical constants are more complex matters of concrete physics and mathematics which will be unraveled in subsequent chapters.

This first article will treat particularly of absolute volume as the basic measure of ingredients, its importance as the basis of co-ordination of the fundamental principles of mixtures, and the history of concrete and concrete research in relation thereto.

ABSOLUTE VOLUME THE BASIC MEASURE OF INGREDIENTS

The problem of making good and uniform concretes, correct in volume, strength, texture, slump or flow, and with economy, is one for which the solution is being sought, now, as in the past, by engineers and concrete makers the world over. While the available literature on concrete making would require a lifetime to read, the current literature on concrete shows a continuing worldwide search for the laws of mixtures. Despite the fact that intensive researches have been in progress and some millions of dollars have been spent in the study of mixtures, since the advent of reinforced concrete in 1855, a law of the strength of mixtures was not established until 1918, and that law is incomplete in itself, being dependent upon an indefinite ratio.

Ancient Bulk Volume Measure a Barrier to Understanding

Concrete physics has been and continues to be a very abstruse subject, as evidenced by this groping and costly progress. Although anyone can mix rock particles, cement and water and get concrete of a sort, the fundamental physics of mixtures continues to baffle scientific research. Concrete is an ancient material and a heritage of ancient ideas surrounds it. This heritage has been a barrier to modern thought in the interpretation and co-ordination of the fragmentary fundamental facts developed by the many workers in modern concrete research. The result is that there are, today, almost as many controversial theories as there are specialists in concrete making, and the lay engineer and contractor is lost between impractical theory and inadequate practice. Today, as in the past, the most troublesome construction problem is how to make good concrete. The conception of measures of proportions of concrete mixtures remains ancient, not modern.

Lack of Understanding of Absolute Volume

We know that very remotely in the past the common formula of proportions was one basket of cementing material to two of sand to four of rock, etc., *by bulk volume, including the variable proportions of voids between particles of the various ingredients.* Bulk volume is an indefinite measure varying from about 0.1 (for diatomaceous earth) to 0.9 (for well graded and compacted gravel) in absolute volume of respective solid ingredients, and research of concrete mixtures employing this scientifically meaningless measure has given meaningless results from which one conclusion could be deduced in one case and the opposite conclusion in similar cases. The data of research of concrete physics are, therefore, a welter of confusion. Despite some important discoveries we are still in the age of confusion in scientific knowledge of the physical laws of concrete mixtures. This lack of understanding of absolute volume as the basic measure of proportions is and has been the barrier to progress in concrete technology.

Ancient Uses of Concrete

Concrete, if made honestly and with sufficient knowledge of essential measures to meet the conditions of use, is a durable material peculiarly suitable in numerous qualities for vast modern requirements and uses. The Egyptians employed a natural hydraulic cement which is found sound after 4,000 years. The Carthaginians made a natural cement concrete, and portions of their structures built 2,300 years ago are still standing. The Romans made a puzzolan cement concrete, and the dome of the Pantheon, 142 ft. in diameter, is of such good quality that it has withstood the destructive forces of eighteen centuries and is sound today. In view of the employment of the rudimentary bulk volume as the measure of ingredients and the consequent variations in quality of the concrete, ancient concrete structures were not always durable, as is evidenced by early repairs and replacements thereto, by complete obliteration of parts; and it is most likely that disintegration in a decade or less was sometimes the experience with ancient as with modern concrete.

Bulk Volume Measures

The ancient and prevailing measure of aggregates in concrete is the "loose-moist bulk volume," a unit measure of which varies from 0.4 to 0.8 in absolute volume of rock solids and, likewise, 0.6 to 0.2 in voids or air space. "Loose-dry bulk volume" has been used extensively as the basis of measure in laboratory and research tests and varies from 0.45 to 0.85 in absolute volume. The American standard measure of aggregates is the "dry-rodded bulk volume," which varies from 0.5 to 0.9 in absolute volume of solids. "Inundated bulk volume," devised by Bertin about 1921, varies from 0.45 to 0.85 in absolute volume of solids.

The Error of Bulk Measure

The "density," or absolute volume of solids in a unit bulk measure varies, with the physical character of the particles, maximum size, grading, moisture content and degree of compacting, from 0.1 to 0.9, considering aggregates, cements and dry admixtures. In other words, the "voids" or air space in the bulk measure vary from 0.9 to 0.1, and this variable air space in the bulk measure is the error of the bulk measurement.

This error of the bulk measurement causes corresponding variations in the quality of the concrete in yield, strength, density, impermeability and durability. The effects of its use in concrete research have been erroneous results and conclusions and the consequent failure of an enormous expenditure of labor and money in research to develop a knowledge of concrete mixtures adequate for modern requirements.

Weight Measure Is Indefinite

Some workers in concrete research, realizing the futility of bulk volume as the basic measure of ingredients, have tried weight proportions as basic, with results similar to the bulk volume basis of measure. Weight is an indefinite measure, as it is merely the various attractions of gravity exerted upon the various ingredients, and the specific gravities of the ingredients entering into concrete vary from less than unity for light-weight aggregates, to unity for water (the basis), to 2.7 for common aggregates, to 3.1 for portland cement, to 5.0 or more for heavy aggregates. Weighing is the most accurate *means* of measure, but as a *basis* of mixture proportions it is meaningless except in so far as it represents the absolute volume of the ingredients.

Absolute Volume Measure

French scientists developed the metric system of scientific weights and measures, prior to 1799, and also the relations of weight, absolute volume and specific gravity. Every scientific student is acquainted with these relations, but, with the ancient rudimentary measure of mixtures by bulk volume securely intrenched in the minds of engineers in the past as today, it was not until about 1892 that absolute volume was used in concrete research.

The noted French engineer, René Feret, about 1892, first employed absolute volume as the basic measure of ingredients, including water, and developed the most fundamental law of mixtures:

The volume of concrete produced by a mixture of aggregates, cement and water is equal to the sum of the absolute volumes of aggregates, cement, water and entrapped air (subject to correction for cement soluble in the water). He also developed an equation of strength and pointed to the effect of water on the strength.

Another notable use of the absolute volume as the basic measure of proportions is that by Messrs. Talbot, Richart and Gonnerman, 1921-24, published in the October 19, 1923, issue of University of Illinois Bulletin.[1] The conclusions therein regarding use of absolute volume as the measure of proportions should be read seriously by every worker in concrete research.

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[1] See Bulletin No. 137, Engineering Experiment Station, University of Illinois, Urbana, Illinois.

Municipal Swimming Pool Pays Profit to City Treasury

One Type of Public Construction That Yields Income on Investment

The construction of a municipal swimming pool in communities not favored by natural bathing beaches may well provide a moderate amount of employment and at the same time yield an income on the investment.

Attendance and operating records at Wheaton, Illinois, an outlying suburb of Chicago, show that the municipal swimming pool (size 80 by 120 ft.) provides health and recreation for its citizens, especially children, and returns a profit to the city treasury besides.

Municipal swimming pool at Wheaton, Ill.

RECORD OF MUNICIPAL SWIMMING POOL, WHEATON, ILL.

Year	Attendance	Receipts	Expenditures	Balance
1928[1]	17,500	$4,600	$3,800	$ 800
1929	27,800	7,200	5,300	1,900
1930	32,600	7,800	5,800	2,000
1931	40,200	8,400	6,000	2,400

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[1] Record is for six weeks only.

Wheaton is 25 miles west of the downtown section of Chicago. The town had a population of 7,258 in 1930.

Much Concrete Work in Earthfill Dam

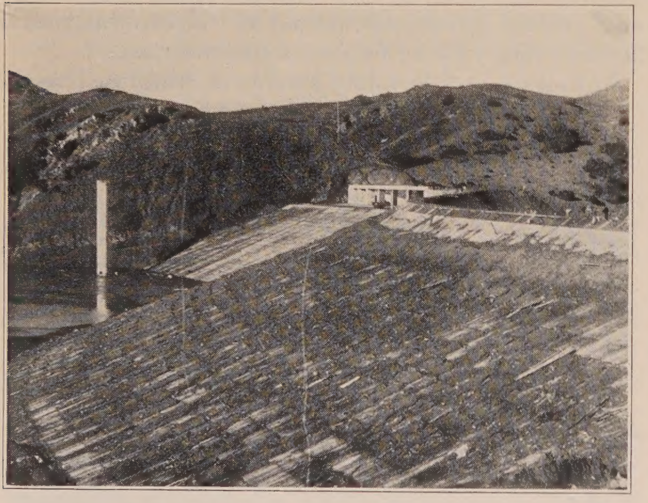
Maintain Careful Field Control of Concrete—Cement Content Is 1.5 Bbl.—41 Per Cent of Cost Is for Concrete Construction

By HOWARD LACY WALTON
Field and Office Engineer on Construction, Fullerton, Calif.

THE extent to which concrete enters into the construction of the appurtenances of an earthfill dam is not generally realized. The surprisingly large amount of concrete actually required is shown by the engineer's records of the recently completed Santiago Creek earthfill dam in Orange County, Calif. The total construction cost was $664,013, of which 41 per cent was expended on reinforced concrete construction, divided into $30,718 for the wasteway, $67,508 for the spillway, $17,345 for the concrete tower, $106,902 for the 6-in. facing slab, and $51,821 for the conduit.

Maintain Field Laboratory Control

Practical laboratory control was maintained over the character and the proportions of the materials to secure maximum density and strength without undue interference with the operations of the contractor. The right was reserved to change the proportions of the concrete from time to time.



Concrete facing slab of earthfill dam. Spillway and tower in background

Cement to the amount of 19,260 bbl. and 905 tons of reinforcing steel were used in the structures. Proportioning was by volume, a 1:2:4 mix being used in most of the work. The gravel was segregated into two sizes, ¼ to ¾ in. and ¾ to 1½ in. The field mix varied from 1:2.3:0.8:2.9 to 1:2.6:1.5:1.9, the average yield being a cubic yard of concrete to 1.5 bbl. of cement.

For tunnel grouting the coarse aggregate was ¼ to ½-in. gravel. The field mix was 1:2.8:1.5, yielding an average of a cubic yard of concrete to 2.02 bbl. of cement.

High Strengths Attained

More than 200 test cylinders were made and broken during the construction period, with the following average results:

	7-day strength, lb. per sq. in.	28-day strength, lb. per sq. in.
Slab concrete	1,380	2,170
Spillway floor	1,915	3,220
Spillway walls	1,845	2,770
Wasteway floor	2,037	------
Wasteway walls	1,980	3,518
Tower concrete	1,542	2,128
Conduit concrete	2,060	2,700

The excavation totaled 300,000 cu. yd. and the embankment totaled 1,100,000 cu. yd. The dam is 130 ft. high and 1,400 ft. long. The reservoir has a capacity of 25,000 acre-feet.

Acknowledgments

The dam was built for the Serrano and Carpenter Irrigation districts and Irvine County by L. G. Le Tourneau, Inc., of Stockton, Calif., from plans drawn by A. Kempkey, of San Francisco. D. W. Albert was the resident engineer.

Concrete spillway, looking upstream

Le Tourneau, Inc. sublet the concrete work. The tower was built by the Johnson Engineering Co. of Los Angeles. The facing slab, spillway and wasteway were built by the Wheatland Construction Co., of Whittier, Calif.

Transit mixers were used in the slab and spillway.

Mixing and delivery of concrete was handled by the Transit Mix Concrete Co., of Pasadena.

Testing was done by Abbot A. Hanks, Inc., of San Francisco. T. P. Dresser, Jr., is their chief engineer; Wainwright Benham was their field representative. Ed Taylor, of San Leandro, was inspector for the districts.

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Highway Engineers Favor Two Sizes of Coarse Aggregate

Seventeen States Now Specify This Method—Uniformity, Absence of Segregation, Improved Workability, Increased Strength and Density, Are Advantages Gained

TO many readers it will be a cause for surprise to learn that the use of two sizes of coarse aggregate in concrete highway work has developed to the point where no less than 17 states now definitely specify such use. Two of the states—New York and Wisconsin—specify three sizes under certain conditions.

Two other states specify two sizes of coarse aggregate in special cases, two states permit the use of two sizes but do not specify it, one other has had considerable experience along this line, and two have tried out two sizes in experimental work. In a word, 24 states out of 43 states that responded to a letter from CONCRETE have had experience with the use of two or more sizes of coarse aggregate; and without a single exception, where comments have been given on the results they have been favorable.

Some of Advantages

Elimination of segregation, improved workability, greater density, reduction in voids, increased strength and greater uniformity from batch to batch are frequently mentioned as advantages gained from the use of two sizes of coarse aggregate.

R. B. Gage, chemical engineer, New Jersey State Highway Commission, writes that they specify two sizes of coarse aggregate for all concrete work, thereby eliminating segregation and producing concrete that is more uniform in composition than could otherwise be attained.

"In New York," says E. C. Lawton, construction deputy, State Department of Public Works, "we generally employ two sizes of coarse aggregate, and frequently three sizes. Our specifications indicate clearly the amount of different size aggregate to be used in different mixes and in different items of work."

W. W. Zass, engineer of construction, Arkansas State Highway Commission, considers that a greater uniformity of mixtures is attained because of their specification requiring two sizes of coarse aggregate. He asserts that segregation is eliminated, and that through the proper manipulation of the various sizes they obtain the least possible voids.

Three Sizes in Wisconsin

The Wisconsin Highway Commission, according to E. L. Roettiger, assistant construction engineer, requires the separation of coarse aggregate into three sizes in all work where the maximum size used is 3 in. Where the maximum size used is 2 in., only two sizes of the coarse material are specified. All coarse aggregate having a percentage composition of 75 per cent or more of igneous or metamorphic material must be classified under the 2-in. maximum size.

C. H. Purcell, state highway engineer, California Department of Public Works, mentions "a dense, workable concrete mixture" as the chief advantage of employing two sizes of coarse aggregate.

"In the District of Columbia," writes H. C. Whitehurst, engineer of highways, Engineer Department, "we are just revising our specifications and have specified a separation of coarse aggregate on the 1-in. sieve. It is expected that a more uniform and better graded aggregate will be obtained under this provision."

The practice in Alabama, says L. M. Dinsmore, office engineer, State Highway Commission, is to specify two

Seventeen states now specify the use of two or more sizes of coarse aggregate in concrete highway work. Four of these have included this requirement for the first time in 1932. Seven or eight other states have had satisfactory experience with this method of proportioning, but do not, for the present, specify it.

These and other facts are discussed in this digest of letters received from the highway engineering departments of 43 states (including the District of Columbia), in response to inquiries addressed to them by "Concrete."—The Editors.

sizes, ranging from ¼ to 1 in. and ¼ to 2 in., of gravel produced in that state.

Texas Uses Two Fine Sizes

"In Texas," says Gibb Gilchrist, state highway engineer, "we have used two sizes of coarse aggregate and two sizes of fine aggregate in a great number of projects. We find that the percentage of voids in the fine aggregate has as much influence on the workability of the concrete as the percentage of voids in the coarse aggregate. In going into the extremely low cement factors, we have in practically all cases found it necessary to use two sizes of fine aggregate. All our design work is based on absolute volumes."

H. C. Weathers, division engineer of tests, State Road Department of Florida, says they employ two sizes of coarse aggregate "not for our advantage, but for the advantage of the material producer." Presumably the purpose is to permit the use of a wide range of sizes in order to avoid the needless expense of crushing the larger sizes.

Michigan Begins Using

Michigan is one of several states in which two sizes of coarse aggregate are being specified for the first time in 1932. The purpose of this modification, writes C. M. Ziegler, deputy commissioner, Michigan State Highway Department, is to obtain more uniform grading. Oregon, likewise, is making this a definite requirement for the first time in 1932, according to S. H. Probert, office engineer, State Highway Commission. The same is true of the District of Columbia, as previously stated, and of Delaware. In the last-named state, writes Frank S. Pritchett, testing engineer, Delaware State Highway Department, two sizes of coarse aggregate were used on two projects in 1931, as a result of which the 1932 specifications require coarse aggregate to be proportioned in this manner. Prevention of segregation in stock-piles, and greater uniformity of concrete, are the advantages observed.

J. D. Monette, office engineer, Mississippi State Highway Department, says their practice is to grade coarse aggregates into three classes, with maximum sizes of 1 in., 1½ in. and 2 in., respectively. Certain percentages of the different sizes are then specified for the various designed mixtures.

Formerly Specified Three Sizes

From North Carolina John D. Waldrop, state construction engineer, State Highway Commission, writes: "For the past four years pavements have been constructed in this state in which the coarse aggregate was separated, first into three sizes, then later into two sizes. The use of separated coarse aggregates enables the grading of the material to be much better controlled, resulting in a more uniform gradation and a constant void content in the coarse aggregate. The addition of a certain percentage of uniform coarse aggregate in a mix with a given volume of mortar will produce concrete which will display more uniform compressive and transverse strengths. The use of additional coarse aggregate in the mix lowers the cement content, and, besides making a concrete of more uniform strength, it reduces the cost of the pavement proportionately."

"Two sizes of coarse aggregate are specified for concrete base and concrete pavement in Ohio," says Neal Moler, assistant engineer, bureau of construction, State Department of Highways. "This has been satisfactory, for the practice has helped to eliminate segregation and it has produced greater uniformity of successive batches."

"Better control of the mixtures, together with higher strengths," are the advantages of two sizes of coarse material reported by H. S. Kerr, chief engineer, Utah State Road Commission.

More Claims of Greater Uniformity

In Vermont, where two sizes of coarse aggregate are proportioned separately by weight, Hubert E. Sargent, commissioner of highways and chief engineer for the State Department of Highways, asserts that "we have found great advantages in this practice. It produces concrete that is uniform in workability and in quality, and, therefore, costs less to manipulate."

T. C. McCrory, chief engineer, State of Washington Department of Highways, mentions "greater uniformity from batch to batch, and greater uniformity among aggregates from different producers" as the principal advantages of using two sizes of coarse aggregates.

Specified in Special Cases

T. H. Cutler, chief engineer, Missouri State Highway Department, writes that his department specifies two sizes of coarse aggregate on special jobs. The advantages observed are less segregation of the coarse aggregate, and more uniform workability.

The practice in Maine, says Lucius D. Barrows, chief engineer, State Highway Commission, is to require two sizes of coarse aggregate only in cases where the contractor fails to provide uniformly graded material. In the last two years it has not been found necessary to enforce this provision of the specifications.

Georgia and Indiana Practice

In Georgia and Indiana two sizes of coarse aggregate are permitted, and in the latter state this method of proportioning coarse aggregate was used on one project in 1930 where central mixing plant concrete was supplied. "In that case," says Wm. J. Titus, chief engineer, Indiana State Highway Commission, "uniformity in the concrete manufactured at that plant was obtained, as would be expected where the gradation of the coarse aggregate was controlled to obtain such uniformity."

Samuel Eckels, chief engineer, Pennsylvania Department of Highways, writes: "We have experimented with the use of two sizes of coarse aggregate and feel that this method assists in preventing segregation."

Minnesota has also experimented with two sizes of coarse material on one project, according to J. T. Ellison, chief engineer, State Department of Highways.

Becoming an Established Practice

From the fact that more than half the states have had satisfactory experience with the use of two or more sizes of coarse aggregate, that more than a third of the states make this method of proportioning a definite requirement, and that four of these are doing so for the first time in 1932, it appears that this method is becoming a well-established practice.

Economy and Smooth Finish From Wood-Fibre Board Forms

Interior Decorative Paint Applied Directly to Concrete Surface—Form Work Detailed in Advance—Construction and Erection of Form Panels

The fifth article of a series describing the use of wood-fibre board in concrete form work, each complete in itself, is here presented.

A smooth interior finish, which permits the application of decorative paint directly to the concrete surface, and the consequent elimination of plaster, are some of the advantages obtained.

The final article of this series will describe the use of fibre board in the form work for a concrete arch bridge.—The Editors.

ECONOMY of construction and a smooth concrete surface for the interior finish were the results obtained by the contracting organization of Leslie Colvin on the new Indianapolis Bell Telephone Co. building, still under construction. Like the majority of Bell Telephone Co. office and exchange buildings, the floor system is the beam-and-girder type. The finished surfaces of all columns, beams, girders and slabs, with but few exceptions, were specified to be exposed concrete, painted.

Items of General Construction

The approximate area per floor is 19,000 sq. ft. The total gross area of supported floor slabs and roof is approximately 179,000 sq. ft. The cubic content of the building is approximately 2,800,000 cu. ft.

The building has a structural steel frame, fireproofed with concrete. Floor panels are solid slabs of reinforced concrete construction. Girders and floor beams on column centers are structural steel, fireproofed with concrete, but the intermediate beams are of reinforced concrete construction.

Re-use of Fibre Board Forms

The net contact area of forms was approximately 138,000 sq. ft. of floor slab surface, 131,000 sq. ft. on beams and girders, and 73,000 sq. ft. on columns, making a total of 342,000 sq. ft. Wood-fibre board to the amount of 80,000 sq. ft. was used as the form material, so that, on the average, this material was used 4.3 times. The contractor is authority for the statement that the surface obtained from the last use was in every way equal to that obtained from the first. The face of the board was kept in good condition by wiping down the surface with oil, between re-uses.

Details of Fibre Board Beam Sides

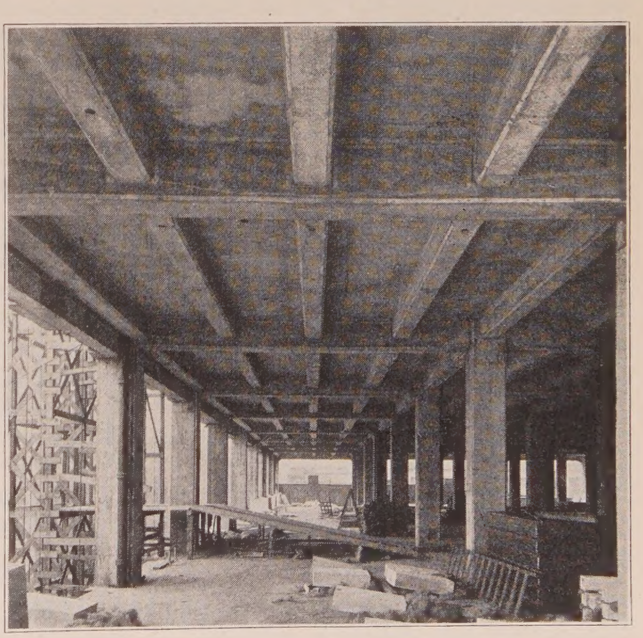
An unusual departure from the general practice of constructing fibre board beam and girder forms is that in this particular case the slab panel carried the molded chamfer strip in place of milling it to the top rib of the beam side.

Figure 1 shows a typical cross-section of form work for the fireproofed steel beams centering on the column heads. Beam sides were constructed of ¼-in. fibre board supported by a skeleton wood frame. This frame was built up of 1-by-4's running parallel to the beam, supported by vertical 2-by-4 battens spaced 2 ft. apart. The battens rested on a 2-by-4 plate, that was blocked at the bottoms with a 1-by-4 strip.

The top 1-by-4 pieces on the beam and girder sides were rabbeted to receive the ¼-in. fibre board. Beam sides were made up to take care of the maximum depth of beam or girder. An adjustable centering plank was used for this purpose, and when adjusted in place it was lined with ¼-in. fibre board.

Form Work for Floor Slabs

Slab panels were built of 1-by-4 boards nailed 8 in. center to center, to 2-by-4 joists spaced 24 in., as shown in Figure 2. These joists were saw-cut at the ends, to



True alignment of beams and smooth finish of underside of floor slabs are shown here

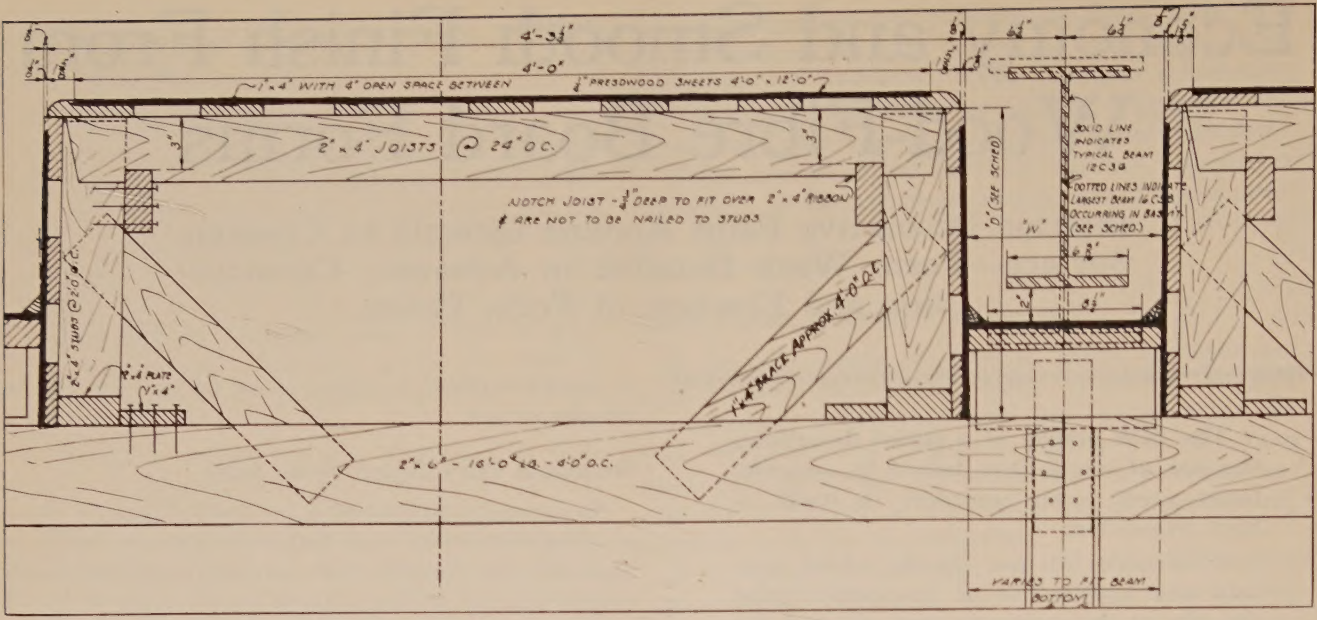

4'-3½"
4'-0"
1"x4" WITH 4" OPEN SPACE BETWEEN
¼" PRESDWOOD SHEETS 4'-0" x 12'-0"
2" x 4" JOISTS @ 24" O.C.
3"
NOTCH JOIST - ¼" DEEP TO FIT OVER 2" x 4" RIBBON
& ARE NOT TO BE NAILED TO STUDS
2" x 4" STUDS @ 2'-0" O.C.
2" x 4" PLATE
1" x 4"
1" x 4" BRACE APPROX 4'-0" O.C.
2" x 6" - 16'-0" LG. - 4'-0" O.C.
6¾"
6¾"
"D" (SEE SCHED)
"W"
SOLID LINE INDICATES TYPICAL BEAM 12C36
DOTTED LINES INDICATE LARGEST BEAM 16 C 58 OCCURRING IN BASEMENT (SEE SCHED.)
2"
8½"
VARIES TO FIT BEAM BOTTOM

Figure 1. Cross-section of form work for beams

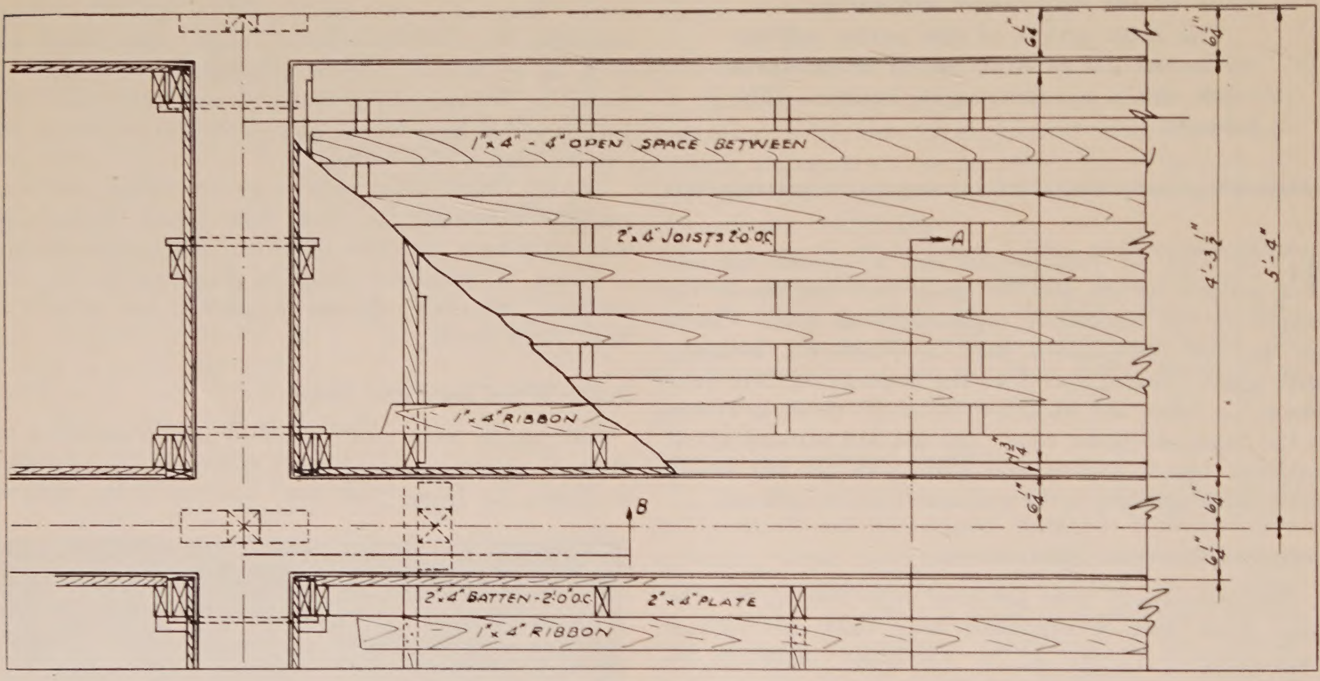

1" x 4" - 4" OPEN SPACE BETWEEN
2" x 4" JOISTS 2'-0" O.C.
A
1" x 4" RIBBON
B
2" x 4" BATTEN - 2'-0" O.C.
2" x 4" PLATE
1" x 4" RIBBON
4'-3½"
5'-4"
6¼"

Figure 2. Details of form panels for floor slabs

permit flexibility, and they were notched, as shown in Figure 1, to fit over stringers in place of wood joists, the latter being the usual custom. These joists acted as spreaders and insured rigidity in the beam and slab form panels. On each panel end a 1-by-4 strip was nailed across the two end joists to be used as lateral bracing for the girder sides. The edges of the wood-fibre board were backed with wooden strips.

Chamfer strips were used at all corners of columns, beams and girders, to provide a beveled effect on all horizontal and vertical members.

Forms Detailed in Advance

Fibre board forms were detailed in advance of the job to meet a predetermined progress schedule. The form panels were made up on the job site and handled from one floor to another with an outside swung crane.

The illustration of the interior shows typical ceiling panels, this view extending about two-thirds of the length of the building. The true alignment of the beams and girders and the smooth finish on the concrete surface are clearly evident in this picture. In the completed structure these surfaces will be painted.

Acknowledgments

The architects of this building are Bohn, Vonnegut & Mueller, of Indianapolis. The general contractor (Leslie Colvin, of Indianapolis) did the form erection and concrete work.

The wood-fibre board employed in the form work on this job was "tempered presdwood," manufactured by the Masonite Corporation, Chicago, Illinois.

Keeping Watch on Quality of Cement

Why Independent Testing of Delivered Cement Is Necessary — Many Methods of Sampling Cement — Chemical and Physical Tests Required

By D. B. RUSH
Manager, Cement and Concrete Dept., Robert W. Hunt Co. Chicago, Ill.

In this article, the fourth of a series of seven, the author describes the methods of procedure involved in keeping watch on the quality of cement delivered to construction work.

The three remaining articles will discuss the inspection and testing of reinforcing steel and aggregates, the molding and testing of concrete cylinders, and field supervision.—The Editors.

CEMENT TESTING

We have just had to reject quite a quantity of portland cement. This particular rejection was made on the strength of 7-day briquettes, according to A. S. T. M. Spec. C-9-30. We are convinced that the management of this particular mill did not know that the material they had sold did not pass the requirements.

Why Independent Testing Is Necessary

The manufacture of portland cement is one of the most standardized industries in the world and one that is supposed to be closely controlled by mill chemists and physicists. Why, then, is it necessary to run independent tests on the product after it is made? It is necessary to make independent tests on portland cement because it is a commercial product, and any commercial product is subject to variation in the raw materials from which it is made, and in the human element that controls its manufacture. The purpose of independent inspection is a guard against the possibility that unfit material will be shipped to the job.

Cement Testing Procedure

The procedure of cement inspection should be divided into two parts—first, the sampling of the cement, and second, the testing of the samples taken. Each of these parts is just as important as the other. The sampling of cement is often supposed to be just a routine job that must be gone through in order to obtain something to test. The fact of the matter is that the present A. S. T. M. Specifications permit of two separate and distinct general methods of sampling, and each one of these general methods of sampling may be done in several different ways. These different ways of sampling depend upon the design of the particular cement mill or shipping station.

In any event, the two general methods comprise, first, a system in which a single clear-cut sample of cement is taken, properly transported to the testing laboratory and properly tested. The second method is that of making up a test sample by combining small samples taken from different parts of the shipment. Now, if all of the cement in each shipment were used in one batch this second method would be absolutely proper and sufficient; but where the shipment is to be used in concrete batches of ¼ yd., ½ yd. or even 1 or 2-yd. batches this method of sampling simply assists in permitting unsatisfactory cement to pass the test.

Methods of Sampling

This sampling by either method may be done from the conveyor belt leading to the bin, from the bin itself, or from the cars or trucks into which the material is loaded. If this sampling is done from the cars and trucks going to the job, the client knows that the material upon which he receives the report of tests went to this job, and not to some other location. In many of the older types of cement mills, it is entirely feasible and practical to sample a bin of cement after the bin has been filled; but in the more recent installations, it is generally only practical to take samples from the inbound conveyor to the bin. It often takes from 24 to 36 hours to fill a good-sized bin. A sampler must remain at the belt during the entire period of the filling of the bin, and having calculated the speed of the material entering the bin, he must take what is known as the grab-sample at regular intervals, so that each one of them represents the barrelage it is supposed to cover. Here again, the combining of a number of samples taken from an automatic sampler merely assists in passing unsatisfactory cement.

Sealing of the Bin

There are conditions under which the sampling and testing of cement in bins is preferable to any other, but these conditions depend entirely upon the exigency of the construction work in hand and are in the minority. Sometimes a great deal of stress is put on the sealing of the bin. Here again, whether or not the bin can be sealed depends upon the design and construction of the cement plant. In many instances it is physically impossible to seal a bin so that cement can not be loaded therefrom.

Sampling from Cars or Trucks

Where cement is sampled from cars or trucks loaded for shipment, the inspector is notified that such a truck or car containing a certain number of barrels is awaiting inspection. The inspector takes a sampling tube and a supply of paper bags, as well as serially numbered identification tags, and climbs onto the load. Whether the specifications call for either the individual or composite sample basis the sampler must by all means take samples from each end as well as the center of the car, for quite often a car or truck has been loaded from two or three separate bins of material. The sample to be tested, whether it be individual or composite, should weigh at least four pounds. The sack, if the shipment is in sacks, from which each sample or part of a sample has been taken should be identified with a serially numbered tag, so that any later time this particular container may be resampled for a check test, and also so that when the test reports are furnished, they contain the same serial numbers and definitely tie up the shipment with the test report. In this connection it is interesting to know that after the material arrives on the job and is check-tested, if the samples come out of the same bags originally tested the cement check is generally satisfactory; if they do not, the check may or may not be satisfactory. It is also of interest in this connection to note that the bulk of truck shipments during the summer season are loaded out at night, and the sampling and early testing must, as a result, be done at night.

Beginning the Test

Now, having obtained the sample properly, it must first be run through a 20-mesh sieve to take out any lumps or unground clinker that may be present, and a careful inspection of the material should be made during this rough screening. The cement should be rejected if any appreciable amount of lumps are retained on this screen. Bear in mind, however, that it would be impossible for any large lumps to be present in a sample of freshly sacked cement, because almost without exception cement is loaded through a pipe extending into the valve at the lower end of the bag, and the diameter of this pipe, itself, would prevent any lump larger than a walnut passing into the sack.

Chemical Analysis

After this operation the cement must be stored in an air-tight container and properly marked for identification. If a chemical analysis is required by the specifications a small portion of the sample is taken out and upon this the loss on ignition, the insoluble residue, sulphuric anhydride and magnesia contents are determined. Many engineers and contractors, however, are very little interested in the chemical composition of the material providing it satisfactorily passes the physical tests.

Early Physical Tests

What are known as the early physical tests are those (1) of fineness determination—that is, the screening to determine that not more than 22 per cent by weight is retained on a 200-mesh sieve; (2) the setting-time determination, either with the Vicat or Gilmore needle. The standard specifications require that a portland cement shall not develop an initial set in less than 45 minutes, and that the final set must be obtained within 10 hours. This setting-time determination is made upon a neat pat of cement that must be 3 in. in diameter at the edge and ½ in. in thickness at the center of the flat top. (3) The soundness determination is made on a similar pat of neat cement, which after 24 hours of setting in a properly maintained moist cabinet must remain firm and hard and show no signs of distortion, cracking, checking or disintegration when held in a steam apparatus which is maintained at 98 to 100 deg. C. and above boiling water for five hours.

Under ordinary conditions, the average rejection of cement from any of the tests will be at least indicated by one of these three early tests. It is for this reason that cement is often accepted for use on the satisfactory completion of these early tests.

Making and Testing Briquettes

The next operation is the making up of standard briquettes for testing in tension at the ages of 24 hours, 3, 7 or 28 days. Each sample of cement requires a certain definite amount of water to hydrate it properly, and this is known as its normal consistency. The variation in this amount of water required by different brands of cement is considerable. The variation, however, by the samples of the same brand is normally so small that it is negligible. The table of the amount of water required for standard mortars (in the A. S. T. M. Spec.) to obtain a neat cement paste of normal consistency varies from 15 to 30, or exactly 100 per cent, and the percentage of water for 1:3 standard briquettes varies from 9 to 11.5, or a variation of 28 per cent.

Specimen Curing

Next, it is necessary to weigh out the standard Ottawa sand so that the batch will be not less than 1,000 grams of combined sand and cement. The combination of these must be thoroughly mixed dry, and then, after the water is added, thoroughly mixed by hand with rubber gloves. This mortar must be placed properly in the briquette molds, and a pressure of between 15 and 20 lbs. applied with the thumbs. The specimens must next be marked and placed in a moist cabinet until they have attained the age of 20 hours, when they shall be placed in clean water maintained within 3 deg. plus or minus 70 deg. F., and the moist cabinet must also be maintained at 3 deg. plus or minus 70 deg. F., and the humidity of the cabinet should be around 95 per cent. At the expiration of the water curing period, listed in the standard specifications as 7 and 28 days, the briquettes are removed from the water and immediately placed in standard specified clips in the testing machine and tested to destruction in tension.

High-Early-Strength Cement

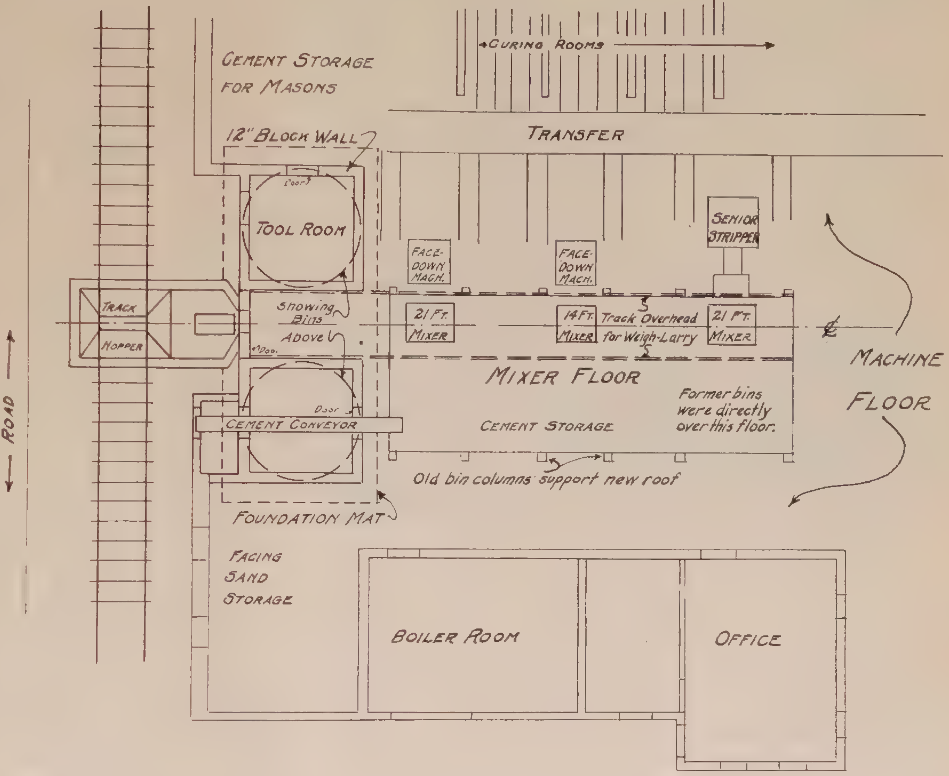
Due to the fact, however, that many cement mills have recently increased the early strength of the cement they manufacture, it is often possible to get results in 3 days equivalent to the 7-day requirements of the specifications. For high-early-strength portland cement the 28-day test is left to the option of the purchaser, the only requirements being the tests at the age of 24 hours and 3 days. The only requirement of the 28-day tests, if they are made, is that the average tensile strength obtained shall be higher than the strength attained at 3 days.

Yet we have had rejections in our general laboratory recently on every separate phase of these specifications.

Cunard-Lang Alterations Show Faith In Concrete Products

Reconstruction in 1931 Simplifies Receipt and Movement of Materials—Concrete Stave Aggregate Bins Supported on 12-in. Block Walls

A PIONEER in the concrete products industry, but still believing in the future of concrete products, is the Cunard-Lang Concrete Co., of Columbus, Ohio, manufacturers of concrete block, building tile, and garden furniture. Evidence of their faith is shown in the remodeling of their plant when they might merely have repaired it. This was accomplished with remarkable economy.



Plan of new arrangement. The mixer floor and location of mixers have not been changed

Organized in 1909

The company was organized in 1909, and after a year in a rented building, erected its own factory. Altered in form, it is part of the present plant. The company has kept step with progress made in the industry in manufacturing methods, and the business has shown a steady growth. In 1923 it became necessary to increase the productive capacity, which was accomplished along with important reductions in manufacturing costs. At that time, new machinery and batch mixers were installed, and overhead wooden bins were built for aggregate.

Build Alterations in 1931

It became apparent last spring that the wooden aggregate bins needed repairing. They might have been repaired and kept in service for a time, but the board of directors approved the policy of Manager John M. Swickard that then was the time to do the job right. Heretofore, all work of enlarging or remodeling had been done under the pressure of an active business demanding production, and sacrifices were made to secure production at the earliest possible minute. With a large stock on hand to take care of current business, the summer of 1931 offered a suitable time to construct according to the best plan rather than the quickest.

Plan of Old Arrangement

The plan above indicates the old arrangement. The new elevator is in the approximate location of the old one. The wooden bins were directly above the mixer floor. The headroom was limited and the light was not good. Water dripping from the aggregates made it necessary to build a roof over the cement storage space.

Formerly, the aggregates were received in cars and were elevated into the bins by an inclined wooden frame bucket elevator, and under the track was a reciprocating plate feeder but no hopper. The lack of a hopper caused much extra shoveling, particularly when the material was received by truck, as is the recent practice.

Aggregate Bins Supported on Block Walls

After considering several plans, the final idea evolved for the construction of the bins was decidedly unique and worthy of consideration at other products plants. A products manufacturer's use of his own product wherever possible not only saves money but is a practical demonstration of what the units will do. In this case, it shows the supporting strength of the block.

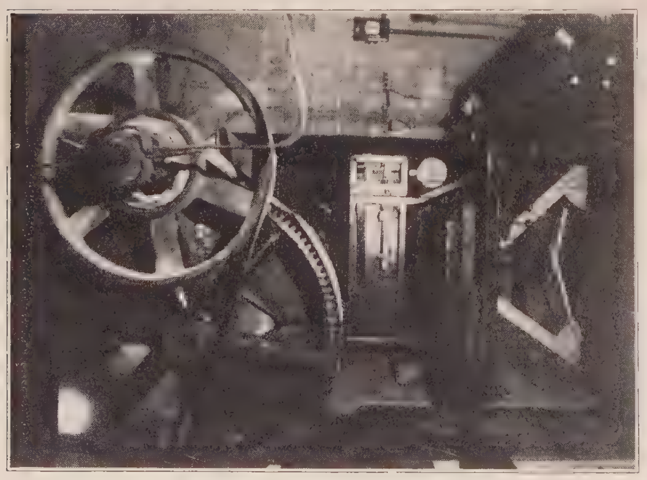
Open squares with walls 20 ft. high and built of 12-in. block support two reinforced concrete slabs on which the two stave bins rest. Storage space under the bins can thus be used. These bins, which are 12 ft. in diameter and 25 ft. high and have a capacity of 125 tons each, improve the appearance of the plant and offer a convincing demonstration of the strength of the block. The psychology is good when prospective buyers visit the plant.

A track hopper of sufficient width and capacity to handle a truckload of aggregate was installed. A large concrete-lined pit to accommodate the hopper and feeder was built. The elevator is a vertical chain and bucket type, having a rated capacity of 45 tons per hour. From the head of the elevator both aggregates flow by gravity into the bins through chutes. Materials may be put into either bin and the elevator may be started or stopped from either main floor or mixer floor by means of dual controls.

The reconstructed plant, showing concrete stave aggregate bins supported on 12-in. block walls

Openings were provided for a belt conveyor through the supporting walls of one bin to handle cement in cloth bags from car door to storage on the mixer floor.

The mixer floor was left almost intact; hence, no resetting of motors and mixers and no realigning of shafts were necessary. Removal of the old bins made it possible to house over the mixer floor in such a way as to make it light and airy.



Weighing hopper under bin gates ready to receive material

Measurement of aggregates by weight was adopted, and a weighing hopper large enough to hold a full charge for the mixer was installed. The hopper is motor-driven along a track above the mixer and is controlled by a cord. Pulling on the cord starts the motor. When it is released, the motor stops. This is a valuable safety feature. A view of the interior is shown, with the weighing hopper under the bin gates ready to receive material. The controls of the bin gates may be seen to the left of the scale dial.

The construction work was done principally by regular employees, thus giving them additional work.

The Advantages Gained

Summed up, the Cunard-Lang Concrete Co. has gained these advantages:

(1) Permanent bins, 250 tons capacity, which can be changed or moved, and require little upkeep.

(2) A much improved working space on the mixer floor.

(3) An improved measuring device for the aggregate, with longer mixing time, greater ease and safety for the mixer man.

(4) Improved general appearance of the plant.

(5) A demonstration of the strength of their block, of value in selling.

(6) An improved and more economical aggregate handling system.

All this was done, including tearing down the old structure, at a cost under $7,000.

Acknowledgments

The results reflect much credit upon John M. Swickard, the manager. He studied, planned, listened to the many proposals advanced, and finally combined the best of the ideas into the layout described. Acknowledgment is made to H. G. Collins, concrete engineer of the Lehigh Portland Cement Co., for his work on the design of the layout and concrete work; to George M. Friel, through whom all the equipment was purchased and who took interest in the work; to the Columbus Conveyor Co. for their service, and to the Marietta Concrete Corp., who supplied and erected the stave bins.

Chicago Block Manufacturers in Annual Meeting

The Chicago and Suburban Concrete Block Manufacturers' Association held its annual business meeting in the assembly room of the Portland Cement Association on April 19.

Following the business session, the meeting was addressed by W. D. M. Allan, manager of the cement products bureau of the Portland Cement Association, who gave an illustrated talk on new developments in the concrete masonry industry. Subject matter discussed in detail included the wall stability tests at the University of Illinois and the manner in which the results of those tests will aid the industry. New developments in concrete ashlar masonry, in the use of color, and in cultivation of the sound-deadening properties of concrete units, were also described and illustrated.

EDITORIAL

Secondary Roads to Support Heavy Traffic

FRED W. SARGENT, president of the Chicago and North Western Railway, recently urged all railroads to co-operate in the establishment of a nation-wide motor trucking service as an adjunct to railway freight service.

Commercial use of hard-surfaced roads has not developed by accident, nor has it reached its present volume because of any special business acumen possessed by the managements of motor transport companies. Primarily, the motor transport business has flourished because it meets the general demand for convenience, speed and economy in freight shipments.

If, as now seems inevitable, the railroads will in time enter this newer field of transportation, shipments by motor truck will increase by leaps and bounds. Highway engineering departments must be prepared for this expected increase in heavy traffic by continuing to design and build highways that will support such traffic without requiring undue expenditures for maintenance.

Highway engineers may find that they have been devoting too much thought to the development of so-called secondary roads, especially where such roads are built by inferior types of construction. If this country is to experience a rapid expansion of motor transportation, as now seems probable, a road built for secondary traffic may become a primary road over night.

It is a difficult matter to predict whether a particular road will be carrying secondary or primary traffic in 5 or 10 years from today. Highway engineers will render their respective states and local communities a better service if they build secondary roads of a type of pavement that is capable of supporting heavy motor truck traffic when the need arises. When cost of maintenance is taken into account, as it should be, the better pavement will cost the least, even over a short period of years.

Road Construction No Place for Retrenchment

THE chamber of commerce of Allentown, Penna., has reminded the state administration in no uncertain terms of the folly of so-called economy that curtails or suspends work on the construction of needed improvements such as concrete roads.

The abrupt curtailment of concrete road construction in that state in 1931, the chamber of commerce points out, was partly responsible for a decrease of nearly 2,000,000 man-hours of labor in the cement mills of the Lehigh Valley district.

Added to this loss are the losses due to the curtailment in the production of coal, gypsum and other ingredients employed in the manufacture of cement, and in the production and shipment of sand, gravel and stone that would have been utilized in the concrete if road construction had been continued under a full head of steam.

This year several other important states have embarked on this same type of false economy. Through drastic reductions in mileage, diversion of highway funds to other uses, and through various other acts of political juggling, the natural development of highway construction is being crippled and unemployment is being intensified in states in which a truer appreciation of values might have been expected.

Several national organizations representing the construction industry are fighting valiantly for the continuation of highway construction programs in keeping with the country's needs. All other construction organizations, as well as individual leaders of the industry, should lend every possible form of assistance to these national associations.

Receiving Bulk Cement Shipments by Rail

RAILWAY shipment of bulk cement in carload lots seems destined to undergo rapid development during the next few years.

Several cement companies have, for some years, employed specially constructed company-owned railway cars for bulk shipments.

Recent developments, however, have served to bring the use of bulk cement railway cars within the reach of all cement companies, thereby placing such service at the disposal of all cement users who have at hand the rather simple facilities required to receive the cement.

One of these developments is a new railway tank car, equipped with the necessary self-unloading mechanism which delivers the cement to the conveying mechanism at the plant of the user.

Another is a covered hopper car recently placed into service by at least three large railway companies, for use in shipping bulk cement and similar materials. With these cars, which, in fact, are but slightly altered coal cars, the cement is delivered by gravity to the conveying mechanism and bins at the point of destination.

Ready-mixed concrete plants, concrete products plants and reasonably large construction projects, if located adjacent to railway sidings, will be in a position to take full advantage of this method of receiving their cement shipments.

PROGRESS—In a Page

Current activities in research, in matters pertaining to concrete and cement, as being carried on or completed by various organized groups.

Load Tests of Tile-and-Joist Floor Slab

LOAD tests of a tile-and-joist floor slab, 6 ft. 6 in. wide, 37 ft. long and 8 in. thick, supported on three concrete piers that provided clear floor spans of 17 ft. 6 in., have been conducted by the U. S. Bureau of Standards, Washington, D. C.

The floor system tested is a one-way reinforced type of combination hollow tile and concrete floor slab construction. It consists of rows of special shaped tiles with 1:2½ cement-and-sand mortar joists 2 in. wide spaced 13 in. center to center between the tile rows. Each joist is reinforced with steel bars. There is no concrete topping over the tiles, and the compressive stresses are borne by the mortar joists and the tiles. Each joist contained a ⅝-in. diameter round bar and a ½-in. square bar for resisting tensile stresses in portions of the slab subjected to positive bending moments. The ½-in. square bars were bent up to lie near the upper surface of the slab in regions of negative bending moment.

When the slab was 39 days old it was loaded with pig iron until failure occurred, under a load of 300 lb. per sq. ft.

Tests of Cinder Aggregates

AN investigation has been made by the U. S. Bureau of Standards covering 59 samples of cinder aggregates obtained from 48 plants manufacturing cinder concrete building units. The investigation included the determination of the grading, weight per cubic foot, hardness and soundness of such aggregates used in the industry. The weights of the aggregates when in the dry rodded condition as described in the "Standard Method of Test for Unit Weight of Aggregate for Concrete (C29-27)" of the American Society for Testing Materials ranged from 46 to 77 lb. per cu. ft. The fineness moduli of the aggregates ranged from 2.9 to 5.4.

As a measure of the hardness of the cinders, 2,500 grams of the particles of each sample retained on a No. 8 sieve were ground in a ball mill under standardized conditions. The percentage of each which was retained on a No. 8 sieve after the test was taken as a measure of hardness. These values ranged from 17 to 65 per cent for cinders from bituminous coal and from 2 to 21 per cent for cinders from anthracite coals.

Investigation of Masonry Cements and Mortars

THE Bureau of Standards of the United States Department of Commerce is continuing its study of masonry cements and mortars.

Certain hitherto unmeasured properties, such as plasticity, water-retaining capacity, and volume change, are being studied. Workability, an essential property in masonry cementing materials, is being given particular attention. The compressive strength of 2-in. mortar cubes is also being determined.

Plasticity is measured in accordance with the principle employed in the McMichael viscosimeter—that is, shearing of the material by a fixed body in a rotated cup. The water-retaining capacity is measured by exposing one side of a thin slab of the mortar to a slight vacuum for various periods of time. This simulates the water-withdrawing action or "suction" of a masonry unit.

Many Contractors File Contract Information

THE Bureau of Contract Information, Inc., 729 Fifteenth Street, Washington, D. C., organized about 5 years ago by committees representing 10 national organizations, recently called attention to the fact that it is an independent bureau, not connected with any other group or association.

The bureau is purely a fact-finding institution which supplies public works officials and others with information from which the responsibility of contracting concerns may be gauged. The information disclosed is given as facts, without recommendation, favor or prejudice, and is based on investigations following the receipt of records filed by the contractor.

The bureau publishes a list of contracting concerns throughout the United States who have thus filed their performance records.

British Standard Eliminates 28-Day Test for Cement

THE British Engineering Standards Association has issued a revised edition of the British Standard Specification for portland cement, which was last revised in 1925. The new specification contains a number of modifications, among which may be noted the elimination of the 28-day test for cement and sand mortar, the 3-day and 7-day tests only being specified; the introduction of a new method for ascertaining the quantity of water to be used for gauging for the tensile strength (cement and sand mortar), setting time and soundness tests; and the reduction of the time of boiling in the test for soundness from 6 to 3 hours.

Revising Simplified Practice on Spiral Steel Reinforcement

THE DIVISION of simplified practice of the Bureau of Standards has asked producers, distributors, and users of concrete reinforcement to consider a new draft of the simplified practice recommendation covering steel spiral rods. The proposed new edition includes the same sizes of rods as were listed in the original draft approved by the industry in January, 1926. The new edition includes a detailed table to facilitate the use of the standard sizes by specifying authorities.

Joints in Concrete Highway Design

—Ideal Joint Fillers Defined in Committee Report
—Determining Required Frequency of Joints
—Means of Strengthening Transverse Joints

THERE is no standard jointing practice in concrete highway engineering. Transverse joint spacings on state highways range from no joints at all to joints at 20-ft. intervals. This wide range in practice is evidence of the difference of opinion on jointing among highway engineers. The object of this paper is to present data and outline methods by which rational joint spacings may be determined, and to point out certain construction and maintenance practices that may lead to joint defects.

Data Obtained from Condition Survey

The material presented is based on data obtained from a condition survey of 6,700 miles of concrete pavement in 11 states, 4 of which were in the northeastern section of the United States, 4 in the south and southeastern, 2 in the middle west and 1 in the far west. Definite conclusions concerning desirable joint spacings are presented and methods for determining the correct spacing for any given locality are outlined. Defects resulting from improper construction and maintenance methods are described in the full report.

The following principal conclusions and indications seem justified as a summary of the material presented in the committee report.

Transverse Expansion Joints

Provision for 1 in. of expansion space for 100 ft. of pavement appears ample under all conditions except for unusual extremes, so far as preventing blow-ups is concerned. The width of expansion joints should be limited to 1½ in.

The possibility of infiltration of soil into cracks and joints should be given consideration in determining the expansion provisions and methods used in maintenance.

Expansion joints should provide for a reasonably free movement of the slab as the joint closes. Observation of a large mileage of pavements reveals the necessity for emphasizing the following widely recognized but many times neglected factors of proper joint construction:

(a) Transverse expansion joints must be placed perpendicular to the subgrade.

(b) Transverse expansion joints should be constructed normal to the longitudinal axis of the pavement.

(c) Transverse expansion joints must provide a full and uniform space for the entire depth and width of the slab.

Transverse Contraction Joints

Slab lengths required to control cracking may be determined from observations of pavements in service by determining the ultimate average uncracked slab length which prevails under different conditions of design, construction or service. The following conclusions apply to determinations of ultimate uncracked slab lengths:

(a) Joint spacings greater than approximately 75 ft. have no major influence on uncracked slab lengths.

(b) Joint spacings less than approximately 75 ft. but greater than that required to control cracking will reduce the ultimate uncracked slab length.

(c) Differences in pavement thicknesses appear to have no material influence on uncracked slab lengths, where the cross-sections are adequate for the loads imposed on them.

(d) Reinforcing will not materially increase the length of the ultimate uncracked slab lengths.

(e) The type and character of coarse aggregate influences uncracked slab lengths, and should be considered in determining joint spacing for crack control.

(f) The type and character of subgrade will have an influence on uncracked slab lengths and should be considered in determining contraction joint spacing.

(g) Uncracked slab lengths decrease with age, the ultimate uncracked slab length being reached in from 5 to 10 years.

The slab length required for crack control is a little shorter (probably about 20 per cent) than the average ultimate uncracked slab length on comparable pavements with long joint spacing. The following indications apply to determinations of ultimate uncracked slab lengths:

(a) Different methods of curing may influence uncracked slab lengths, but differences in the uncracked slab length decrease with age and become quite small at ages of 5 to 6 years.

(b) Uncracked slab lengths on comparable pavements in states having extreme variations in climate, temperature and moisture, and especially where frost plays a part, will be shorter than those in states having more equable climate.

Strengthening of Transverse Joints

Actual thickening of slab ends at transverse joints as a means of strengthening leads, in most cases, to transverse cracking and subsequent breakage at or near the end of the thickened section. Slab ends at joints may be strengthened by the use of dowels placed across the joint, or by the use of special reinforcement. The design and installation of dowels across transverse joints must permit a transfer of load across the joint and a free longitudinal movement of the slab ends. Design and installation requirements gained from observations of dowelled joints in service are as follows:

(a) The hole for the dowel in the expansion material should not be larger than the dowel.

(b) Dowels must be installed parallel to the subgrade and longitudinal axis of the pavement. This requires pro-

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Condensed from report of committee on design and construction of concrete highways, presented at the annual convention of the American Road Builders' Association, Detroit, Mich., Jan. 11-15, 1932.

visions to hold the dowel firmly in place during construction.

(c) Free slippage must be provided on the half of the dowel in one slab. This slippage should be provided by a minimum of space around the dowel.

(d) Expansion space must be provided and insured at the end of the dowel on the free end. This should be in excess of the accompanying joint space.

Longitudinal Joints

Where longitudinal joints divide pavements into integral widths or lanes of approximately 10 ft., longitudinal cracking is eliminated or reduced to a negligible amount.

Pavement edges along expansion or butt construction joints should have the same thickness as outside or free edges of the pavement. Mechanical bond must be provided and insured at longitudinal center joints where the pavement thickness is less than the edge thickness.

The use of a deformed metal center joint, held tightly together with tie-bars, as a means of transferring load across the joint, is well justified by its satisfactory performance in service.

Dummy joints having a groove depth of approximately ⅓ the total depth of slab will satisfactorily control cracking. A dummy or groove type of center joint, held tightly together with tie-bars appears from the limited data available to provide the necessary mechanical bond to assure transfer of load across the joint.

Fillers for Transverse Joints

Bituminous material and various combinations of inert fillers with bitumen have been largely used in the construction of transverse expansion joints. These bituminous joints have in general performed satisfactorily, providing for the more or less free expansion of the slab. They have, however, one fault in common, that of being expelled from the joint space when the pavement slab expands. This requires frequent removal or trimming of the expelled material, to avoid impairment of the riding qualities of the pavement. In addition, it is necessary to refill the joint when the slab contracts. Where such joints have not been refilled, they are left partially open, permitting the infiltration of water-borne soil, fine wind-blown soil, and other inert material. The expansion material eventually becomes replaced or impregnated with soil, which reduces the value and efficiency of the expansion joint.

The ideal form of joint is one using some completely resilient material and offering low resistance to compression, which will not be affected by the elements, or some satisfactory and economical means of providing and insuring an unobstructed joint space. To supply this need there has been placed on the market what is known as the air cushion joint, and a joint material composed of sponge rubber. These have been used to some extent in recent years with satisfactory results.

Road Builders' Regular Annual Meetings Held

The regular annual meetings of the American Road Builders' Association were to be held April 28 and 29 at its offices in the National Press Building, Washington, D. C.

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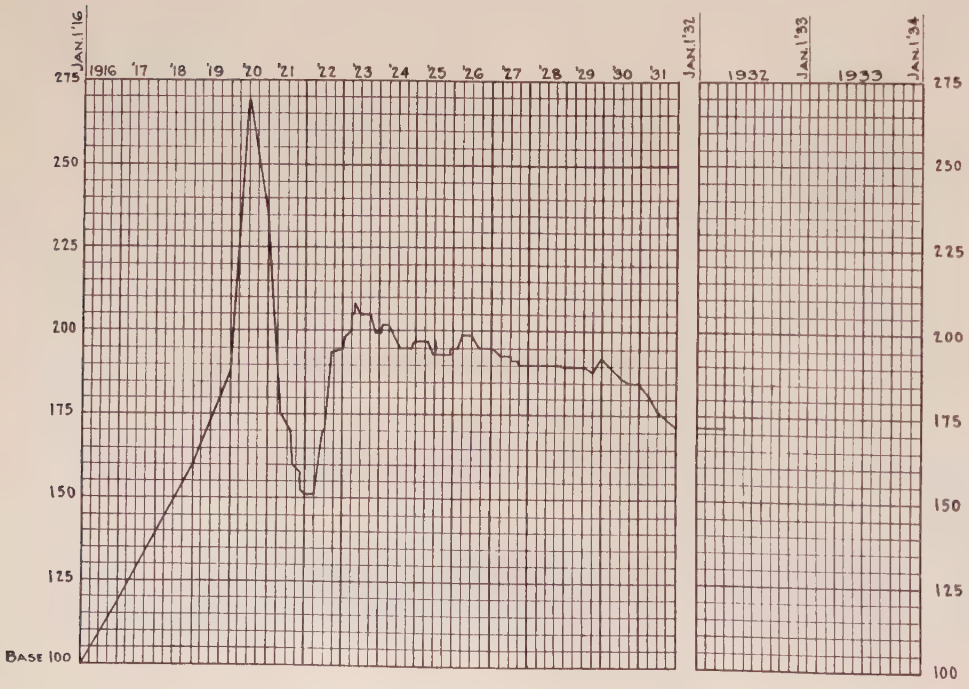
Aberthaw Index of Cost of Building

(Published in the issues of February, May, August and November)



The Aberthaw Index of Cost of Industrial Building for April 1 shows no change from the figure of January 1, and stands at 172. This is equivalent to a cost of $1.81 per sq. ft. of floor area for the 7-story reinforced concrete industrial building used as the basis for computing the index.

Negotiations now in progress toward wage reductions are expected to lower the index, though it is doubtful that the official wage rates will be lower than the wage scales actually being paid on individual contracts.

Use of White Portland Cement to Place Lines Into Concrete Courts in Construction Provides Permanent Marks That Need No Further Attention

Market for Concrete Tennis Courts

Bennett Survey of 242 High Schools Shows Lack of Needed Facilities—Concrete Contractors Can Aid in Promoting Favorable Sentiment

OPPORTUNITIES for local concrete contractors to aid in the promotion of concrete tennis courts as important features of high school facilities are seen in a survey of such facilities, just completed by Paul Bennett, of the department of athletics, Northwestern University, Evanston, Ill.

The Bennett survey covers 242 high schools in Ohio, Indiana, Michigan, Illinois, Wisconsin and Iowa. Only 15 of the 257 high schools to which the questionnaire was sent failed to reply. This fact alone indicates a high degree of interest in the subject.

The complete report which sets forth the results of the survey deals with a broad scope of subjects, including a statement of the tennis facilities at present available, the construction and maintenance of tennis courts of various types, cost of construction, and comparison of the true cost of different types of construction when first cost and maintenance costs are considered over a period of years.

Concrete Courts the Most Satisfactory

Concrete tennis courts are recommended as unquestionably the most satisfactory type of construction, not only because of their lower ultimate cost when considered over a period of years, but also because they are usable during seasons and weather conditions when courts of other types of construction are not usable.

All of these subjects, together with such additional matters as interest in the game, programs of instruction, organized competition, and related subjects, are treated in detail in the full report.

The opinion from 206 of the high schools was that interest in tennis would be greater if better playing facilities were provided. Only 2.5 per cent of all the schools reported playing facilities as "excellent" and apparently satisfactory.

No less than 139 high schools use public courts operated by the city or the park board, 17 have the use of industrial courts, 58 use private courts, 29 use courts belonging to various other owners. In many cases a high school uses courts coming under several of the classes of ownership just enumerated, so that there is some duplication in these figures.

On the other side of the picture is the fact that only 51 of the high schools reporting use their own courts only, while 25 use their own courts along with others.

The use of courts other than those belonging to the high school makes it a difficult matter to conduct courses of instruction or to maintain regular practice periods. The question of maintenance is also a problem, one that often leads to ill feeling. Two-thirds of the schools using courts other than their own reported the arrangements as being unsatisfactory.

A Chance for Promotion

Lack of funds or lack of space, or both, are given almost invariably as the main reasons why high schools do not have their own tennis courts. This suggests at once the opportunity for the promotion of school-owned courts, through the co-operative efforts of concrete contractors and high school athletic departments. By enlisting the support of the local press and of individuals who believe in the value of tennis as a builder of health and character, sentiment can be created to the point where funds will be made available either through direct appropriation by the school board or through private subscriptions.

Minimum Standards Needed

Many tennis courts are built where the space is entirely inadequate, with the result that the space between the back line and the back stop is much too little, or the lateral space between courts is insufficient. Deficiencies of this character detract greatly from the interest in the game.

With these matters in mind, the following items should be observed in the planning and construction of tennis courts:

(1) The distance between the back line and the back stop should never be less than 18 ft.

(2) The back stop should be from 10 to 14 ft. high.

(3) The space between side lines of adjoining courts should be at least 8 ft., and 10 or 12 ft., if possible.

(4) A court should run north and south, and hedges should be provided behind the ends for background.

(5) A court should slope so that it will be a true plane, in order that balls will bounce at the same angle anywhere on the court.

(6) Net posts should be 3 ft. outside the side lines, so that the net may be held at the proper height.

(7) The dimensions of the court proper (for doubles) are 78 by 36 ft. These dimensions are standard the world over.

(8) The ideal plot of ground for one court is 120 by 60 ft. An area 110 by 50 ft. would be satisfactory, but should be considered as the minimum.

Some Details of Concrete Courts

The author quotes from one writer to the effect that concrete courts are not hard on feet and leg muscles, as some players contend, if the player acquires the low running movement of the Californians who are accustomed to them. He then gives the following additional items as points that are applicable to the construction of a concrete court:

(1) The concrete slab should be 5 in. thick, and should be reinforced.

(2) The complete area, including the "runways" at ends and sides, should be paved with concrete.

(3) Dark mineral coloring should be used, to prevent glare.

(4) There should be no dirt surfaced strips between courts.

(5) White lines should be painted on the courts twice a year; or better still, lines made with white portland cement may be built into the court at the time of construction, as shown in the illustration.

(6) Complete specifications for the construction of concrete tennis courts may be obtained from the Portland Cement Association.

Comparative Costs of Courts

Comparative costs of courts of various types are given. These costs are of exceptional interest, inasmuch as they represent average figures obtained by the author, both as to original cost and expenditures for maintenance. The ultimate economy of concrete construction is fully demonstrated.

From the author's experience he estimates the cost of conditioning a clay or stone dust court each spring at $100, while about the same amount must be spent in maintaining it during the playing season. He considers the cost of maintaining a concrete court as *nil*. He estimates the original cost of a concrete court at an average of $2,000, and that of a clay or stone dust court at $800. Based on the replies received to his questionnaire, and on his own observation and experience, he presents the following figures as a fair average comparison:

	Concrete court	Clay or stone dust
Annual interest on original cost, at 5 per cent	$100	$ 40
Cost of maintenance, per year	-------	200
Total annual cost	$100	$240

No comparison is made with asphalt courts. The author's recommendation is that this material should not be considered. He observed several asphalt courts that had large cracks and were rough, and he quotes another writer to the effect that tennis courts of that material are dirty and hot, and extremely wasteful of rackets, balls and shoes. For these reasons he considers concrete as the only suitable hard-surface material at present available for tennis court construction.

Highway Traffic to Increase in West, Survey Indicates

Traffic on the federal-aid highway system in 11 western states, will, in general, increase by 45 to 60 per cent in the period 1930 to 1940, according to a report issued by the Bureau of Public Roads of the U. S. Department of Agriculture.

The federal-aid system is approximately 7 per cent of the total rural road mileage in each of these states and is made up of the important state and interstate routes.

This report is the result of a traffic survey conducted from September, 1929, to October, 1930, in co-operation with the highway departments of Arizona, California, Colorado, Idaho, Nebraska, New Mexico, Nevada, Oregon, Utah, Washington and Wyoming. The investigation was undertaken to obtain essential facts about the present density, type, capacity and distribution of traffic units as a basis for planning highway development to serve present and future traffic.

Coming Conventions

May 9-12—National Fire Protection Association. Chalfonte-Haddon Hall, Atlantic City, N. J.

May 18-19—National Concrete Burial Vault Association, annual meeting. Hotel Statler, Cleveland, Ohio.

June 20-24—American Society for Testing Materials, thirty-fifth annual meeting. Haddon Hall, Atlantic City, N. J.

The Workability of Concretes

Numerous Test Methods Applied to Measurement of Workability—None Entirely Satisfactory—Fine Particles Play Important Part

By RENE FERET

(Concluded from April Issue)

VERY recently Smith and Conahey worked with a ball buried in a vertical cylinder of paste and pulled upwardly by means of a thread attached to the ball, passed over a pulley, and weighted at the other end. For each weight the speed with which the ball rises was measured.

Outside of these methods, Bates and Dwyer have also tried two others. First was the "extrusion cylinder" outside of which the paste is forced by means of a piston through an orifice of fixed dimension, a curve is plotted showing the relation of the displacement of the piston in terms of the pressure. Second, the "capillary tube," which is 2 mm. in diameter and set vertically, through which the paste flows either by its own weight or under the action of compressed air. The fluidity of each paste is indicated by curves, some of which express the loss of pressure in terms of time, and others the speed of flow in terms of pressure. Similar measures can also be obtained by means of a properly modified MacMichael's viscosimeter.

Different Plasticity with Different Cements

The research work conducted in accordance with these methods, particularly those of Bates and Dwyer, brings out that different cements can produce pastes of very different plasticity, which correspond to the differences in workability noted in concretes in which these cements are used. The pastes which are the hardest to deform are those which give the most intimate mixtures and the most workable concretes.

The comparison of neat cement paste can also be obtained by means of several apparatus mentioned further, with which tests have been conducted for mortars and concretes. According to Oden the formation of laitance when concrete is placed under water is due to the simultaneous presence of two different categories of grains, the larger ones remaining in suspension in the slurry formed by the finer ones.

Studying these phenomena by means of mixtures containing various portions of cement and lime in powder form, Forsell found that lime prevents the settling of cement, and that as long as the weight of the cement is in excess of that of water, the proportion of lime necessary remains constant and equal to one-sixth of the weight of water.

The important observations of Bolomey, which deserve more study, indicate that the particles of sand and cement less than one-tenth of a millimeter form with water a sort of emulsion, the density of which must be greater than a certain limit in order that the concrete may be workable.

These particles must constitute at least half of the grains smaller than half a millimeter, and the density of the slurry formed by them and the entire amount of mixing water must be at least 1.75 for soft concretes and 1.90 for plastic concretes. It may be seen from the above that the properties of the pastes formed by water and the extra fine elements of the concrete play in reality a very large role in the workability of the concrete, and it is important to study them with particular care.

SECOND—METHODS FOR MEASURING WORKABILITY

The most widely known test is the slump test, which consists in measuring the amount of slump of a truncated cone of concrete of fixed dimensions under its own weight immediately after the form is removed. It has the advantage of being very simple, and within the reach of the most modest job, but its indications are often discordant and fail for lean mixtures or those containing large stones.

I have tried to modify this test (first with mortars using smaller volumes) by placing a plate on top of the truncated cone on which weights were successively placed, and the corresponding increase in slump measured. This procedure did not prove very effective.

Along the same line of thought, Biffi employed a "plasticimeter" based on the reduction in height of a truncated cone caused by the fall of a weighted plate under certain predetermined conditions. For the dry mortars, he noticed a considerable slump with crumbling. As the amount of water was increased, the loss of height decreased, passed through a minimum, and then increased for the soft mortars. He adopted as normal plasticity a consistency somewhat softer than that producing minimum slump.

Flow Table Test

Instead of measuring loss of height, it is possible to measure the deformation of concrete by the increase in the diameter of the base of the truncated cone. This is the principle of the "flow table," also frequently used, but especially in research laboratories. By means of this device the concrete is subjected to vertical trepidations under well defined conditions. Perhaps somewhat more precise than the slump test, this method is of a delicate application, and it has been criticized on the ground that it furnishes information on concrete dissociated by the jolts, that is to say, in a state different from its initial one.

Smith and Conahey conceived that this disassociation could be used as a measure of the degree of workability

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Translated from the *Proceedings* of the French Society for Testing Materials, by R. L. Bertin, chief engineer, White Construction Co., Inc., of New York.

of concrete. By means of a vertical annular form, they separated the concrete after it had been spread on the flow table into a central mass and concentric rings, and determined the proportions of stone contained in each zone. This procedure did not appear to them as being worth retaining.

Methods by Fall of Concrete

Various methods have been employed, principally in Germany, which consist in causing the concrete to slide on planes or inclined gutters, either fixed or agitated by well defined impulses, and to measure either its speed of flow or the weight retained on the gutter, noting at the same time if the mixture segregates into its constituents.

Chapman has caused to fall under predetermined conditions a mass of concrete contained in an elastic envelope, and measured the deformation of the envelope after the fall.

Jackson measures a mass of concrete contained in a tremie, having the shape of a truncated cone, which mass he lets fall from a height of 30 cm. on a disc 30 cm. in diameter, and then weighs the quantity retained on the disc.

Munsell had proposed to modify this apparatus by arranging at the base of the tremie two lines of iron bars simulating reinforcement, which would be agitated during the flow of the concrete.

Tokujiro Yoshida has tried without success to force concrete upwardly out of a vertical cylinder and to measure the diameter of the pile thus formed on a horizontal plate fastened to the top of the cylinder. This same experimenter, on the other hand, declares himself quite satisfied with the method which he calls "drop device," which consists of pouring the concrete in the form of the truncated cone on two horizontal plates overlapping end to end, which can be separated suddenly over a plane located 20 cm. below the plates. As the amount of water contained in the concrete is increased, the diameter of the pile formed after the fall first decreases, then reaches a minimum, varying with the workability of the concrete, and then again increases. (See Figure 7, *Proceedings* of A. C. I., 1927, p. 426.)

Miscellaneous Methods

Another attempt by Yoshida, which remained fruitless, consists of measuring the force necessary to extricate upwardly a wooden cone buried in the concrete.

The plasticimeter of Emley is based on the principle that the more a substance is plastic, the more water it will retain when applied on an absorbent surface, and the less effort will be required to cause it to spread. It is composed of a plate of plaster of constant absorbing power, on top of which is molded a pat of concrete. The top surface of the concrete is rapidly brought in contact with a disc slightly conic in shape. The bottom plaster plate is given a uniform rotating motion, and the work required to rotate this plate and the corresponding drag on the upper disc are measured simultaneously. The time when the first cracks appear in the concrete is also noted.

Purrington and Loring have attempted to measure the workability of concrete by means of the amount of electrical energy necessary to agitate the concrete in a mixer. A considerable part of the energy is spent to overcome other resistance, which without doubt results in errors even though the measure of current begins while the apparatus is idling.

Smith and Conahey have settled concrete by jolting it in a vertical cylindrical envelope constructed of flexible metal, which was subsequently pressed laterally, the force required for each reduction in diameter of a half-inch being measured. The method, although not very sensitive, appeared to them as being susceptible of being perfected.

Pearson and Hitchcock placed on the table of a flow table a receptacle containing concrete, on top of which they placed vertically a steel bar with a spherical end, and measured the workability by the area of the curve, giving the penetration of the bar in terms of the number of trepidations.

Smith and Conahey have perfected this apparatus by replacing the single bar by three solid bars in which the penetration is caused by the blows of a miniature drop hammer. Workability is measured by the work spent in causing the bars to penetrate the concrete eleven inches. Thanks to this method, which gives them great satisfaction, they have noticed that certain concretes spreading equally on the flow table exhibit very different penetrations. With the leanest mixtures, the workability is notably better for medium spreads than for drier and wetter consistencies. (See Figure 8, *Proceedings,* A. C. I., 1928, p. 34.) However, the manipulation of this apparatus would without doubt be too delicate to be employed regularly on the job.

THIRD—CONCLUSIONS

Summing up, in spite of the diversity of the numerous methods which have been briefly reviewed, none seems to give entire satisfaction.

However, the results obtained seem to bring out, particularly those expressed numerically and shown in this paper, that for each mixture of solid materials there exists a proportion of water, which produces a concrete of maximum workability, and also that for given materials the workability of the concrete improves as the ratio of cement to the inert materials increases. It is to be noticed that Yoshida's experiments indicate that the influence of the proportion of water on workability becomes less marked as the amount of cement in the mix becomes less, while the opposite is indicated by the tests of Smith and Conahey. The two methods, therefore, do not seem to furnish information on the same property.

The most important problem appears to be to define the granulometric composition, which should be selected for the mixture in order to produce a concrete most easily placed without excessive consumption of cement, without reducing materially the other principal qualities, such as resistance and density.

As it has been indicated above, workability is a very complex quality, the manifestations of which must be carefully investigated for the various prevailing conditions, from which it follows that the solution to the problem must be different, depending upon the aim sought.

So far it seems to me that we must distinguish between the aptitude of the concrete not to separate itself by sizes of materials during the transportation, and that of lending itself to perfect distribution in the forms with the least amount of work. These two qualities could be called "cohesion" and "plasticity," and should be studied separately by methods suitable to each one.

Writing a Purchase Specification for Ready-Mixed Concrete

Time Allowance for Delivery — Who Decides When Requirements Are Fulfilled? — Removing Sources of Dispute — Delivery During Cold Weather

By R. B. YOUNG
Consulting Engineer, Toronto, Ontario, Canada

(Concluded from April Issue)

THE preceding installment of this article covers the problems involved in the actual production of ready-mixed concrete, and the manner in which specifications should be written so as to protect the consumer without unduly hampering the producer. The present concluding installment deals with the delivery, inspection, tests and acceptance of ready-mixed concrete.

Allowable Time for Delivery

Here again the requirements are somewhat different for the central-mixing plant than for truck-mixer plants. The author has had little experience with the former and does not feel competent to suggest what clauses are necessary in the case of this type of operation; but general experience seems to indicate that low-slump concrete can be successfully transported in non-agitating bodies, while for slumps above 2 to 2½ in., agitating-type bodies are necessary.

A question that has troubled many engineers and architects when asked to permit the use of ready-mixed concrete is, "What length of time should be permitted between the mixing and placing of the concrete?" It appears from tests made that the strength of concrete is not materially reduced even if it is not placed for as much as 3 hours after mixing; but the consistency of the wet mixture, as measured by the slump, is reduced greatly. The Tentative Specifications for Ready-Mixed Concrete, of the American Concrete Institute, suggest that the elapsed time between the addition of the cement to the aggregate and the placement of the concrete in the forms be not more than one hour. This limits the time that may elapse between the charging and discharging of the delivery unit to about 40 minutes.

The author is inclined to the view that the elapsed time could safely be increased to 1¼ or 1½ hours. As hauls which limit truck equipment to one trip every two hours are seldom profitable, there is little likelihood that the producer will use this additional time to increase the average haul. More likely it will save for him certain loads that are delayed in transit or held on the job, that are entirely suitable for use, but are now returned.

When concrete is delivered by truck mixers, the same question of elapsed time enters, but in a slightly different way. Some operators add the gauging water to the mixer just before mixing, in which case the only moisture in contact with the cement prior to this time is the moisture contained by the aggregates. Other operators put the gauging water into the drum with the rest of the batch and some combine these systems. Most engineers will argue that the limiting time specified for delivery of central-mixed concrete should apply here, and this view will probably prevail when specifications are written; but when the bulk of the water is not added until the batch is mixed, 2 or 3 hours can elapse between batching and mixing with little or no detriment to the quality of the concrete.

Delivery During Cold Weather

A great deal of concrete is now placed during the winter months. Years of experience with job-mixed concrete have taught most engineers and architects to specify that the aggregates and water are to be heated during this period, and the temperature of the freshly mixed concrete held between some such limits as 50 and 120 deg. F. It seems to the author that for ready-mixed concrete the only provision needed is that the concrete when delivered shall fall within a certain range of temperature to be set by the buyer, and he would suggest for consideration 60 to 80 deg. F. for temperatures down to 25 deg. F. and 75 to 95 for all temperatures below this.

The maximum rate at which delivery is to be made by the producer is one which should be a matter of agreement between him and his customer, and the best place for such a clause is in the contract proper rather than in a specification for quality. Some limiting time between successive batches is a restriction thought desirable by many.

Inspection of Plant and Materials

The buyer of concrete should have the same right as any other purchaser of material or equipment to enter freely the plant of the producer and examine and test the raw materials and the different processes that enter into its manufacture. The cost of this inspection should be borne by the buyer and not by the producer.

Certain specifications for ready-mixed concrete require that the producer's plant shall be under the direct supervision of a competent engineer. Unquestionably, it would benefit the industry if every plant had an engineer familiar with concrete technology responsible for the quality of the product, but so would the foundry business if every

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Presented at second annual convention of the National Ready-Mixed Concrete Association, Pittsburgh, Penna., Jan. 25 and 26, 1932.

foundry had a metallurgist in charge, or the clay products industry if every brick and tile plant had a ceramist in charge. It seems to the author that one is on questionable ground when one includes his requirement in a purchase specification, for it is hardly enforcible, as it leaves to the buyer the decision as to who is or is not a competent engineer in this line of work. If there is any doubt in the buyer's mind as to the ability of the producer to meet the specification, he should not buy from him.

Tests and Acceptance

These two subjects are so intimately related that they can best be discussed together, for the same principles govern the requirements of both.

The buyer purchases ready-mixed concrete to be delivered to some designated location, and it is his right to demand that the concrete should meet the requirements of the specification when and where delivery is taken. The producer is only responsible for the quality of the concrete up to the time of delivery, for he has no control over the concrete after the buyer receives it, and the latter can entirely alter its properties by his treatment of the concrete subsequent to the time it leaves the producer's hands.

For these reasons, it would seem to be desirable and necessary to base all tests and acceptance on the condition of the concrete at the time and place of delivery. The concrete should be sampled and slump tests made then, and not when the concrete is in the forms. The supervising architect or engineer will probably require that his samples be taken from the forms. It is here that difficulty is apt to arise, for tests are not likely to be made at both points. In case of argument, the producer either has to accept the former's tests or prove that the concrete has been abused. In order to protect themselves in case of dispute, many producers have an independent inspection company sample and test their concrete at the point of delivery, and while the practice can hardly be made mandatory, the producer who does so is wise.

Who Decides When Specifications Are Fulfilled?

The buyer of ready-mixed concrete has a right to insist that the product he receives shall meet the specification in all particulars, and if it does not, he need not take it. But who shall decide when the specification is met? Certainly not the seller, nor has the buyer any more right to insist that his decision shall govern. There should be some way of determining performance independently of either party to the contract.

The buyer, under the inspection provision of the specification, has the right to sample and test the ingredients going into the concrete, he has the right to inspect the various manufacturing processes; and in both cases, if they do not conform to the specification, he has demonstrable facts to deal with in case of an argument.

When it comes to the question of the quality of the finished concrete, there is more room for differences of opinion. As stated previously, quality is usually given in terms of consistency, and either proportions, minimum cement content, water-cement ratio, compressive or flexural strength, or some combination of these. Consistency is measured by means of the slump test and presents no difficulty; the compressive or flexural strength can also be measured if one will await the time required to cure the test specimens; but after a concrete is mixed, about the only possible way the proportions or cement content can be determined is by some system of unscrambling the wet concrete. It is the author's belief that some such test will have to be included in the specification as one of the acceptance tests.

Determining Constituents of Concrete

For determining the proportions from a sample of wet concrete a test which has possibilities for this purpose has been developed by Professor Dunagan of the University of Iowa, and is now being studied by the American Society for Testing Materials. This test has as yet been used for so short a time that data is lacking with which to determine the proper tolerances that should be used with it, but a little experience will remedy this deficiency. The same test could be used to determine the cement content of a freshly mixed concrete, but here again tolerances would need to be established. When the concrete in question has set, another test is available which is also being standardized by the same Society, and for which also tolerances have to be determined.

The Dunagan test might be used as well for determining the water-cement ratio of a concrete mixture, for it is claimed to measure the water in a mix to 1/10 gal. per sack of cement, and to be reliable to ¼ gal., which in terms of water-cement ratio work out to 0.015 and 0.038, respectively. For specification purposes, a test for water-cement ratio should determine it to an accuracy of plus or minus 0.03, which is equivalent to approximately plus or minus 150 lb. per sq. in. at 28 days. If the Dunagan test is as accurate as claimed it practically meets these requirements.

In addition to this, it is necessary to give the producer some leeway in the water content of his concrete. Just what this should be, the author is not prepared to say, but would suggest for study that the average water-cement ratio of the concrete delivered should not be less than the minimum specified and that any one batch of concrete tested should not fall below this minimum by more than 0.05.

If Strength Falls Short of Requirements

A great many cubic yards of concrete are now sold on a so-called strength specification. Such a specification appeals to many buyers as a simple way of shifting to the producer the responsibility for determining the proper proportions required to give the compressive strengths wanted by the engineer or architect, and it appeals to the producer since it gives him a greater opportunity to profit by his knowledge of concrete and a careful selection of the raw materials. The great drawback to this form of specification is the difficulty of determining whether or not the producer has actually delivered concrete of the specified strength, and most specifications are very hazy on this very important point.

The measure of performance for this kind of specification is the test of a hardened specimen of the concrete delivered, and this test is usually made from a week to a month after the concrete was built into the structure. The question always arises, "What happens if these tests do not meet the specifications?" Of course, if the concrete actually does not meet the specification, the purchaser may require its replacement; but this is such a costly procedure for both producer and purchaser that if there were any general likelihood that such an event were probable, few men would enter into this type of contract.

The fact is that with any well-run concrete plant it is a very remote eventuality, and the principal danger from this type of contract is that some accidental condition will affect the tests adversely and the quality of the concrete will be questioned. If this happens and the buyer or the buyers' engineers are unfriendly or uninformed and the producer is unfortunate in not having protected himself by independent tests of his product and a proper understanding with the buyer of what he has contracted to do, he may have a very expensive and nerve-racking experience.

Removing the Sources of Dispute

A purchase specification for ready-mixed concrete should cover these eventualities by definitely stating:

(a) Where and when the concrete is to be sampled.
(b) How the test specimens are to be made, cured and tested.
(c) When the tests indicate that the specification is met.
(d) What procedure shall be followed in case the tests indicate the specification has not been met.

The first point has been covered earlier in this discussion, when it was required that samples should be taken at the time and place of delivery of the concrete.

The second is covered if all tests are required to be made in accordance with the standard methods of the American Society for Testing Materials, with the added provision that all test specimens are to be laboratory-cured under standard conditions after the first forty-eight hours, and that the provisions in no case shall apply to so-called job-cured specimens.

When do the tests indicate that the specification has been met? The obvious answer is "When all of the tests are above the specified minimum." This may be the obvious and logical answer, but it is likely to be uneconomical and unfair.

A Workable Provision for Tolerance

The science of testing concrete is far from being exact, and a group of identical specimens made by skilled men in a well-equipped laboratory seldom have a mean variation from their average of less than 5 per cent, and often much more. Also, practically all of the errors in carrying out the provisions of the standard methods of making, curing and testing concrete give test results lower than the true values. For these reasons, a producer of ready-mixed concrete who has to comply exactly with the foregoing interpretation would have to design his concrete by such a wide margin that there would be absolutely no chance of failure. A reasonable margin of safety should be allowed in designing concrete mixtures, and the 15 per cent required under "Proportions" is expected to do this; but even this does not always provide for the accidents of testing. Therefore, it seems to the author that a tolerance should be adopted something after this character:

"The average compressive or flexural strength at 28 days or other age specified shall not be less than the minimum required by the engineer or architect" and in order to provide for the accidental low test it should be added "that the requirements of the specification shall be considered to have been met if not more than 10 per cent of the tests fall below 90 per cent of the specified minimum." Study of test data may show that other percentages or requirements should be used, but the author's experience would indicate that the above could be easily met by a well-handled concreting operation—either ready-mixed or mixed on the job.

Producer Should Protect Himself

The producer who accepts orders for concrete under any specification cannot escape the consequences if he fails to live up to his contract, but the producer who undertakes to deliver concrete to a specified strength assumes special risks, and he should never forget that fact, and should be certain beyond any doubt that his organization has the requisite knowledge, skill and equipment to carry out its obligations. He also should take all reasonable means of protecting himself against the ignorance or inefficiency of the other parties to the contract.

The Volume of a Batch

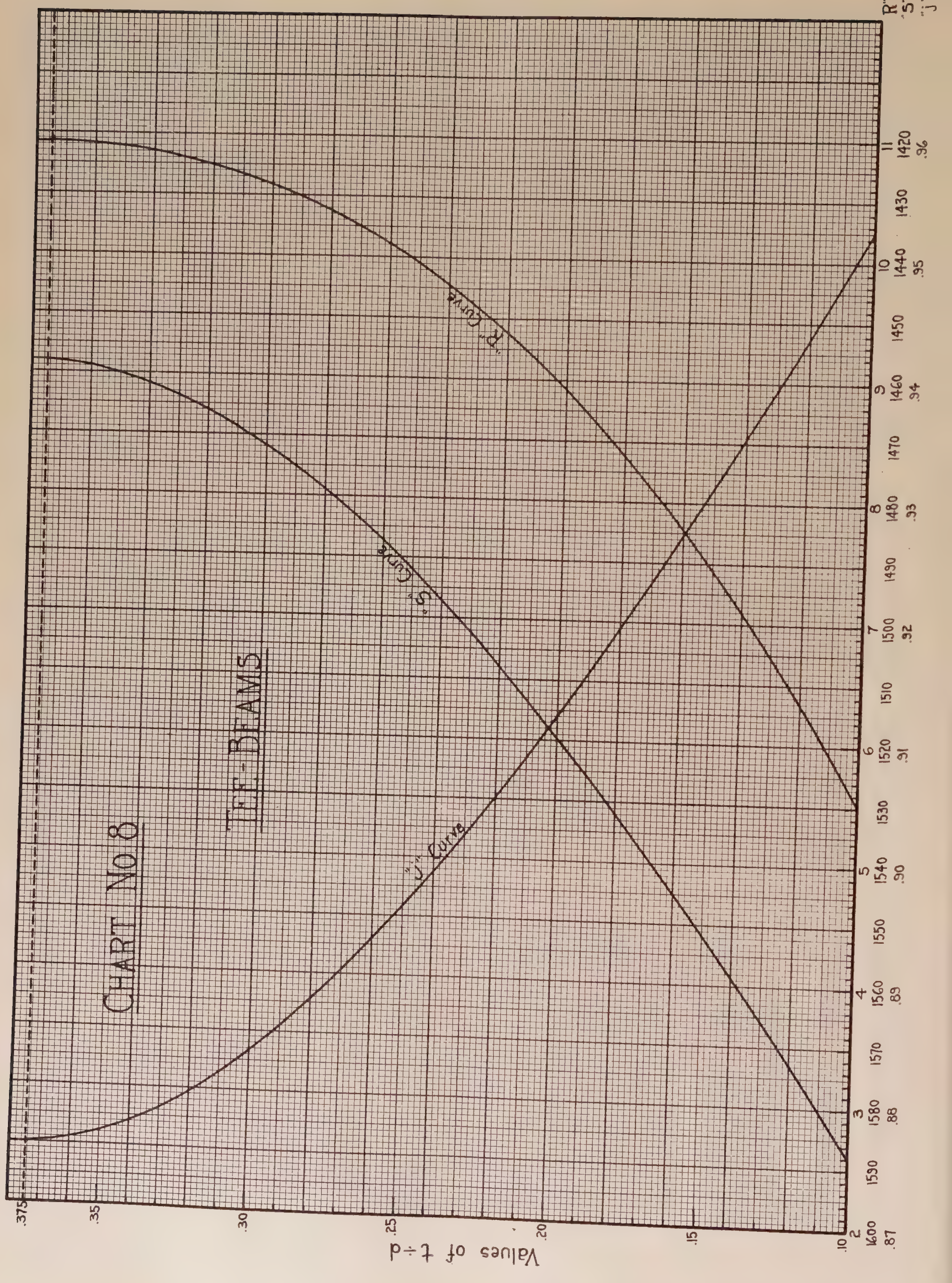
One other item that should be included under "Acceptance" is a statement of how the volume of a batch of wet concrete is to be determined. The simplest method is to consider it the sum of the absolute volume of its ingredients, and for the majority of concrete mixtures the volume calculated in this way should agree with the measured volume within one per cent.

For very lean concretes, for lean mortars and for concretes made of very porous aggregates, such as cinders or haydite, the calculated volumes are not reliable, due either to the presence of a varying amount of air voids in the concrete or to the difficulty of determining the proper specific gravity of the aggregates. For these conditions, the correct volume of any batch may be determined by calculating the weight per cubic foot of the concrete from the weight of test cylinders at the end of 24 hours. Volumes determined in this way will check within 1 per cent with calculated volumes when the mixtures used are free from air voids. It would probably be found satisfactory, if the specifications for ready-mixed concrete allowed either method of determining volumes to be used, with the provision that if the calculated volume differs more than 2 per cent from the volume determined by weighing the test cylinders, the latter should govern.

~ PERSONALS ~

Geoff. A. Saeger, chemical engineer for the Missouri Portland Cement Co. for a number of years, severed his connections with that company on April 1.

Mr. Saeger is a recognized authority on the chemistry of cement and cement manufacturing processes, and has been active in these phases of the work of technical organizations such as the American Society for Testing Materials and the American Concrete Institute.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Cutting Corners in Concrete Structural Design

New Chart Permits Rapid Design of T-Beams—Application to Tile-and-Joist Floor Calculations

VI—T-Beams and One-Way Tile and Concrete Joist Slabs

By J. R. GOETZ*
Structural Engineer, Chicago, Ill.

DUE to the many and varied applications of T-beams to reinforced concrete design in general, it becomes imperative that the designer have a quick and simple means for computing them. Chart No. 8 accomplishes this with a minimum of computation, and it has the advantage of being exact in the results obtained. The usual notation for concrete design has been used, except that a steel coefficient, marked "S" (which will be explained later), has been adopted for convenience.

Tile & Concrete Joists ~ One Way

Slab	d"	j	R	+M'*	b"	Wt. per □'	-M'*	Shear Area	
								No Tile	Tile 1 Side
4+2	4.5	.875	10.93	2660	16	49	1095	15.7	18.7
					17	51	1218	19.7	22.6
					18	52	1327	23.6	26.6
4+2½	5.0	.875	10.93	3285	16	55	1350	17.5	20.8
					17	57	1502	21.9	25.1
					18	58	1638	26.2	29.5
4+3	5.5	.875	10.93	3975	16	62	1630	19.2	22.8
					17	64	1820	24.0	27.6
					18	65	1980	28.8	32.5
6+2	6.5	881	10.65	5400	16	60	2280	22.9	27.2
					17	62	2540	28.6	32.9
					18	65	2770	34.4	38.6
6+2½	7.0	.876	10.93	6430	16	66	2645	24.5	29.1
					17	68	2945	30.6	35.2
					18	71	3210	36.8	41.4
6+3	7.5	.875	10.93	7390	16	72	3040	26.2	31.1
					17	75	3380	32.8	37.7
					18	77	3685	39.4	44.3
8+2	8.5	.900	9.75	8450	16	73	3900	30.6	36.3
					17	75	4345	38.2	44.0
					18	78	4735	45.9	51.6
8+2½	9.0	.888	10.36	10070	16	79	4375	31.9	37.9
					17	81	4870	39.9	45.9
					18	84	5300	47.9	53.9
8+3	9.5	.881	10.71	11590	16	85	4870	33.4	39.7
					17	88	5425	41.8	48.0
					18	91	5910	50.1	56.5
10+2	10.5	.916	8.69	11500	16	82	5955	38.4	45.6
					17	87	6630	48.0	55.2
					18	90	7230	57.6	64.9
10+2½	11.0	.903	9.55	13880	16	88	6540	39.7	47.1
					17	93	7275	49.6	57.0
					18	96	7930	59.5	67.0
10+3	11.5	.893	10.12	16070	16	95	7145	41.0	48.7
					17	99	7950	51.3	59.0
					18	102	8665	61.5	69.3
12+2	12.5	.927	7.76	14530	16	92	8450	46.3	55.0
					17	97	9400	57.9	66.6
					18	101	10230	69.5	78.2
12+2½	13.0	.915	8.74	17720	16	98	9130	47.6	56.5
					17	103	10160	59.5	68.4
					18	107	11070	71.4	80.3
12+3	13.5	.905	9.44	20630	16	104	9850	48.8	57.9
					17	109	10960	61.0	70.1
					18	113	11930	73.2	82.4

Use of Chart Illustrated

The use of the chart is as follows: Given the depth of the T (t) and assuming an effective depth (d), the value of the ratio t/d is obtained. Entering the chart at the left with this value, continue over until the curve "R" is reached, and read the value of R at the bottom. Then, as $M = Rbd^2$ (where M is the moment in foot-pounds), the value of b is found. If this value is satisfactory and is not too large as determined by the building code used, the value of d which was assumed may be fixed as correct. If, however, b becomes too great (or too small) a new d is assumed, and the process repeated.

The value of "S" in the chart is equal to $f_s j \div 12$. Hence, to find the required area of steel, find the value of S from the "S" curve, corresponding to the t/d used.

Then $A_s = \dfrac{M}{Sd}$.

In finding the value of the unit shear, the true values of "j" should be used, rather than the fixed value for rectangular beams. These are given from the "j" curve. The units used in the chart were for $f_s = 20{,}000$ and $f_c = 800$.

Values in Table Taken from Chart

The table of tile and concrete joists was computed from the curves in Chart No. 8, and needs little explanation. It should be noted, however, that a column has been included showing the allowable negative bending moment and also a column of shear areas with the thickness of the tile wall on one side included. In order to take advantage of this increase in area, the joints of the tile in adjacent joists must be staggered. The bending moments shown are in foot-pounds.

Cincrete to Ship Block to Chicago by Lake Boats

Shipments of large orders of cincrete block to Chicago for building projects there will be made via chartered lake boats during the coming summer by the Cincrete

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*Formerly chief engineer for Ben Marshall, architect, Chicago, Ill.

Corporation of Milwaukee, Wisconsin.

One order has been obtained for 300,000 units, according to L. E. Pitner, vice-president and general manager. Another order calls for 100,000 blocks to be used in construction of a 17-story public building.

High-Early-Strength Cements Tested by Bureau of Standards

Progress in Tests During 1931 Reported—Determining Strengths and Resistance to Freezing and Thawing

An investigation of the properties of the new class of cements, generally known as high-early-strength portland cements, was begun by the U. S. Bureau of Standards in November, 1929. Concrete cylinders, 6 by 12 in., are made in a 1:2:4 mix with water-cement ratios of 6.5, 7.5 and 8.5 gal. per sack of cement. Specimens are made for each of four different initial storage conditions (first 24 hours after mixing) and four subsequent curing conditions. The initial storages are in air at 70, 90 and 110 deg. F., and in a thermally insulated box in a 70 deg. room. The curing storages are in air at 70 deg., damp room at 70 deg., outdoors, and alternate freezing and thawing. Strengths are determined at 1, 3, 7, 28 days, 1 year and at a later age for the damp-cured specimens; at 7, 28 days, 1 year and a later age for the air-cured specimens; at 1 year for the outside specimens; and at 300 cycles for the freezing and thawing specimens. The temperature changes during the first 24 hours were determined by means of thermo-couples inserted in the cylinders. Volume changes are determined by means of micrometer measurements made upon glass squares in the ends of the specimens, the distances between which are read at various times.

Results Obtained to Date

The specimens for 12 different cements have been made. The one-year tests have been completed on four cements.

The results thus far obtained show the following:

1. With the exception of one cement which fell considerably below all the others, the one-day strength for the 70 deg. initial storage varies from 900 to 1,470 lb. per sq. in. for the lowest water-cement ratio, and between 390 and 590 lb. per sq. in. for the highest water-cement ratio.

2. For any particular cement and water-cement ratio, the one-day strengths for the different initial storages generally increase in the following order: 70 deg., insulated, 90 deg. and 110 deg. This order is, however, not maintained in the later ages. The one-year results so far obtained show that the curing conditions have a much greater effect than the initial temperatures.

3. The temperature rise during the first 24 hours is highest for the insulated storage. Generally the cylinders giving the highest temperature rise have the highest one-day strengths.

4. The cylinders stored in the air of the laboratory shrink; those stored in the damp room expand. The length measurements do not show any definite influence of the various water-cement ratios or initial storage conditions. The freezing and thawing specimens, which are read at the end of a year, and at 300 cycles, show greater expansion than the corresponding specimens cured damp at 70 deg.

Chicago and Philadelphia Sectional Meetings of Institute

Sectional meetings of the Concrete Reinforcing Steel Institute were held at the Hotel Knickerbocker, Chicago, on April 20, and at the Sylvania Hotel, Philadelphia, on April 8.

Early sessions were devoted to reviews by the president of the Institute activities for the last fiscal year, followed by discussions of matters of mutual interest. Regional conferences were held in the afternoons.

Fire Protection Meeting

The annual meeting of the National Fire Protection Association will open on May 9, and continue for three days, at the Chalfonte-Haddon Hall, Atlantic City, N. J.

How One Architect Promotes House Building

With a few common sense facts boiled down to post card size and mailed to prospective home builders a Chicago architect is doing his bit toward the encouragement of home building during the present low construction costs.

More general resort to efforts of this character, on the part of architects, might result in starting something.

SURE TAXES ARE HI!

BUT

$5,000 WORTH
of building can now be
had for — — — — —
$4,000
I am told. Enough
Saving to pay your high taxes for 10 years.

Taxes will not be so high very long either.

SEE THE WISDOM OF BUILDING NOW.

LYMAN J. ALLISON
LICENSED ARCHITECT
115 So. Dearborn St. Phone Central 0728

HOW TO DO IT

✦ **Questions and Answers** ✦
Consultation and Comment

A department devoted to the solution of problems encountered in concrete work. Readers are welcome to add to or improve upon the suggestions printed and to submit their views for possible publication.

Thin Layer of Concrete Over Old Slab

We have a large underground vault, with a concrete floor slab covering one-fourth of the floor area.

This slab was placed seven months ago. We now wish to place a concrete floor over the entire area, about 1½ in. above the surface of the old slab.

Will it be possible to apply a layer as thin as 1½ in. to the old slab so that it will adhere to the existing concrete and sustain heavy loads?—A. B. D., Springfield, Mass.

It should be a simple matter to place a 1½-in. layer of concrete over the existing concrete slab. It will be necessary to handle it somewhat as you would place a floor finish of cement mortar on a hardened structural concrete slab. This finish, as you know, is often placed to a thickness of ¾ in. The old slab, as usual, must be thoroughly cleaned by scrubbing, and a cement-and-water mixture or grout of the consistency of thick paint should be brushed over the old concrete just before the new concrete is placed.

For the coarse aggregate, however, you should specify a small size, either pea gravel or trap rock or similar hard aggregate that passes the ½-in. screen.

If a good, hard, coarse aggregate is selected, along with good sand, and if the workmanship is up to standard, no trouble will be experienced in sustaining heavy loads.

Specifications covering the complete process of placing so-called "heavy-duty" floor finish will be found on pages 37 and 38 of the August (1930) issue of CONCRETE.

Plans for Concrete Houses

Can you refer me to any book of plans of concrete dwelling houses that may be published in the United States? I am interested in particular in 5-room and 6-room houses.—G. N. G., Auckland, New Zealand.

The Architects' Small House Service Bureau, 7 W. Madison St., Chicago, Illinois, has designed and supplies a number of plans of 5-room and 6-room dwelling houses in conjunction with the Portland Cement Association. These plans, for the most part, contemplate the construction of walls of concrete masonry units (coated with stucco) and first floors of reinforced concrete.

Proportions for Stucco and Plaster

What proportions are generally recommended for portland cement stucco and plaster for exterior work?—L. T. C., Monroe, La.

For exterior portland cement stucco work, for all coats, the proportions commonly employed are 1:3 (one sack of cement to 3 cu. ft. of sand). As a rule, a plasticizer is added to "fatten" the mixture. If the plasticizer is hydrated lime, the quantity should not exceed 10 lb. to the sack of cement. If it is a proprietary product, the manufacturer's specifications will serve as a guide.

The proportions for exterior portland cement plaster work, as on the outside face of concrete or masonry foundation walls, should be the same as for exterior stucco work. The same is true of plaster on metal or wire lath, except that hair or fiber is added to the plaster for the scratch coat, to the amount of ¼ bushel per sack of cement.

Repairing Cracks in Concrete Water Tank

In a reinforced concrete industrial water supply tank in this city several vertical cracks have developed through which a gradually increasing amount of leakage is occurring.

We have been engaged to make the necessary repairs to stop the leakage. What do you suggest as the proper procedure in a case of this kind?—R. E. B., Wheeling, W. Va.

The tank should be emptied and repairs made on the inside face of the wall. Cut away a strip 5 or 6 in. wide and at least 1 in. deep, taking care not to cut or injure the steel reinforcement. In addition cut a groove farther into the crack, an inch or so in width and perhaps 2 in. in depth, wherever this may be done without injury to the reinforcement. The purpose of this additional work is to get rid of as much as possible of the partly disintegrated concrete adjacent to the crack.

Then, after cleaning out all loose particles, fill both the groove and the cut strip with a bituminous filler material or a quick-hardening portland cement-and-sand mortar.

Design of Concrete-Incased Steel Beams and Girders

As a structural designer I am interested in practical formulas for the design of concrete-incased steel beams and girders in which both the concrete and the structural steel are considered as resisting stress.

Being a new subscriber to CONCRETE, *I am not familiar with what has been published on this subject. Can you enlighten me on this point?—A. R. B., Lima, Ohio.*

Formulas for the design of concrete-incased structural steel beams and girders, where both the concrete and the steel are figured as taking stress, are given in an article by O. H. Mengering in the June (1930) issue of CONCRETE, pages 35-37. Two minor corrections of the formulas appear on page 37 of the following month's issue.

The June (1930) issue, on page 34, also contains a condensed report of tests of full-size floor panels consisting of reinforced concrete slabs and concrete-incased steel beams and girders. These tests were conducted under the auspices of the Western Society of Engineers.

New Books and Pamphlets

New Engineering Handbook

General Engineering Handbook, first edition. By Charles Edward O'Rourke, editor-in-chief, and 29 associates. Published by McGraw-Hill Book Co., New York and London. Flexible cover; 921 pages, 5 by 8 in.; numerous tables, diagrams and illustrations. Price $4.00.

The purpose of this book has been well attained, for it assembles a great amount of fundamental engineering data in usable form, within the limits of one volume. The subject-matter is divided into 31 separate sections, each dealing with a specific branch of engineering.

Sections of particular interest to engineers who specialize in the use of concrete as a structural material include "Highways," by Thomas R. Agg; "Reinforced Concrete Structures," and "Stresses in Framed Structures," by Charles Edward O'Rourke; "Engineering Materials," by Herbert H. Scofield; "Foundations," by Roland P. Davis; and "Mechanics," by Alfred P. Poorman.

Investigations by Building Research Board

Report of the Building Research Board, for the year 1930, issued by the British Department of Scientific and Industrial Research. Published by His Majesty's Stationery Office, London, England. Paper cover, 136 pages, 6 by 9½ in., illustrated. Price 2s. 6d. net.

Among the reports of tests and investigations contained in this publication are many dealing with cement and concrete. The constitution of cement, resistance of cement to sulphate solutions, fineness of cement, shrinkage of concrete, strength tests of rapid-hardening cements, the effect of storage conditions on cement, construction joints in concrete, and the action of sea water on concrete, are a few of the subjects treated.

New Building Code of Underwriters

Building Code recommended and published by the National Board of Fire Underwriters, 85 John St., New York. Fifth edition, completely revised, 1931. Cloth, 316 pages, 5 by 7½ in., illustrated.

This new edition of the N. B. F. U. building code, like former editions, contains a recommended ordinance providing for fire limits, and regulations governing the construction, alteration, equipment, repair or removal of buildings or structures, as commonly set forth in city building codes.

Working stresses for reinforced concrete work are somewhat higher than in former editions, and hollow concrete masonry building units are given full recognition.

Yard and Railroad Safety

Cement Mill Yards and Railroads. Industrial Safety Pamphlet No. 6 for the Cement Industry. By J. R. Cline and Stewart J. Owen, Jr., published by the National Safety Council, Chicago, Ill.

This is a 14-page leaflet approved by members of the Cement Section of the Council and a special committee of leading safety engineers. Safe practices at possible danger points, as they exist in the departments referred to, are described in detail and illustrated.

ORGANIZATIONS

American Association of State Highway Officials; W. C. Markham, Executive Secretary, 1222-24 National Press Building. Washington, D. C.

American Concrete Institute; Harvey Whipple, Secretary, 641 New Center Building, Detroit, Mich.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 West Grand Ave., Chicago.

American Road Builders' Association; Chas. Upham, Engineer-Director, National Press Building, Washington, D. C.

American Society of Civil Engineers; Geo. T. Seabury, Secretary, 33 West Thirty-ninth St., New York City.

American Society for Testing Materials; C. L. Warwick, Secretary-Treasurer, 1315 Spruce St., Philadelphia, Pa.
Thirty-fifth annual meeting, June 20-24, Haddon Hall, Atlantic City, N. J.

Associated General Contractors of America; E. J. Harding, Managing Director, 222 Munsey Bldg., Washington, D. C.

Building Officials Conference of America; Col. John W. Oehmann, Secretary, 1253 Lawrence St., N. E., Washington, D. C.

Cast Stone Institute; L. A. Falco, Secretary, Chapel St. and Blatchley Ave., New Haven, Conn.

Cement Institute; Luther G. McConnell, General Manager, 11 East 44th St., New York City.

Concrete Masonry Association; Jack Franklin, Secretary, 7071 Plankinton Bldg., Milwaukee, Wis.

Concrete Reinforcing Steel Institute; M. A. Beeman, Secretary, Tribune Tower, Chicago.

Engineering Institute of Canada; 2050 Mansfield St., Montreal, Quebec.

Joint Committee on Standard Specifications for Concrete and Reinforced Concrete; F. R. McMillan, Secretary, 33 West Grand Ave., Chicago.

National Board of Fire Underwriters; W. E. Mallalieu, General Manager, 85 John St., New York City.

National Concrete Burial Vault Association; J. H. Stuart, Secretary-Treasurer, Bremen, Ohio.
Annual meeting, May 18-19, Hotel Statler, Cleveland, Ohio.

National Crushed Stone Association; J. R. Boyd, Secretary, 1735 14th Street, N. W., Washington, D. C.

National Engineering Inspection Association; B. H. Witherspoon, Secretary, P. O. Box 1115, Pittsburgh, Pa.

National Fire Protection Association; Franklin H. Wentworth, Secretary, 40 Central St., Boston, Mass.
Annual meeting, May 9-12, Chalfonte-Haddon Hall, Atlantic City, N. J.

National Lime Association; Norman G. Hough, Secretary and Manager, 927 Fifteenth St., N. W., Washington, D. C.

National Ready-Mixed Concrete Association; V. P. Ahearn, Secretary, 545 Munsey Building, Washington, D. C.

National Sand and Gravel Association; V. P. Ahearn, Executive Secretary, 545 Munsey Bldg., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, 937 Leader Bldg., Cleveland, Ohio.

National Terrazzo and Mosaic Association; U. F. Durner, Secretary, 815 West St. Paul Ave., Milwaukee, Wis.

Northwest Concrete Products Association; W. P. Hews, Secretary-Treasurer, Yakima, Wash.

Portland Cement Association; Edward J. Mehren, President; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

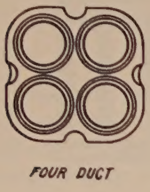
Rail Steel Bar Association; H. P. Bigler, Engineering Secretary; Builders' Bldg., 228 N. La Salle St., Chicago, Ill.

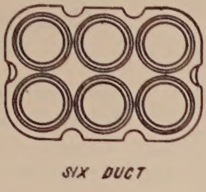
Wire Reinforcement Institute; R. D. Bradbury, Director, National Press Bldg., Washington, D. C.

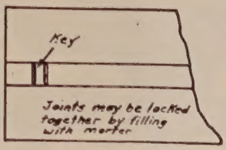
Wisconsin Concrete Products Association; Jack Franklin, Secretary-Treasurer, 425 East Water St., Milwaukee, Wis.

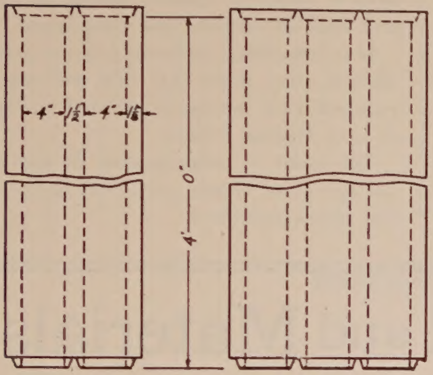
New Concrete Multiple Conduit Manufacture and Use

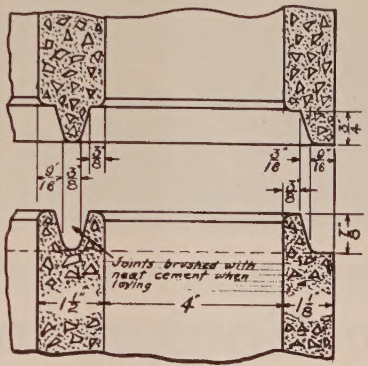
Packer-Head Process Employed—Density and Strength—South American Installation—Service Given by Chicago Units











The International Telephone and Telegraph Co. is installing on an important project in Uruguay concrete multiple conduits manufactured in Montevideo on a new type of equipment perfected by the McCracken Machinery Co., Sioux City, Ia. The unit is 4 ft. long and provision is made for tight joints to prevent the infiltration of ground water and silt. For low tension telephone lines it is not necessary to joint each duct independently. The conduit unit in use in Uruguay is a 4-duct unit.

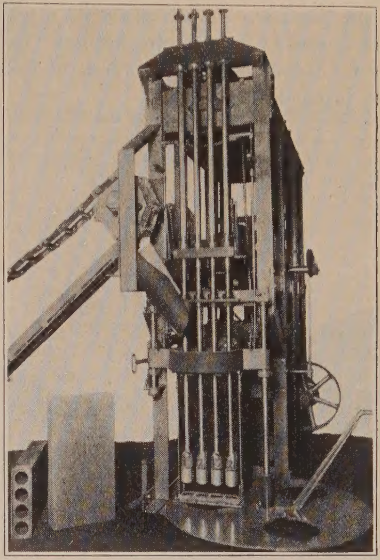
For high tension power lines, each duct is jointed independently so that all parallel ducts are completely insulated from each other.

Common practice in North America is to use 6-way and 4-way conduits and in some cases 2-way conduits. The new McCracken machine is said to produce 30 duct ft. of 6-way conduit, 20 duct ft. of 4-way conduit and 10 duct ft. of 2-way conduit per minute. Only five molds are used, as the units are packed so densely that molds may be removed at once.

The packer-head process is utilized. The forming heads of the machine revolve in a stationary mold. The packing member packs by a wedging action, which is followed by a trowelling action. The result is a dense unit, the interior of each duct trowelled, the bore accurate, and all ducts of adjacent conduit units aligning perfectly in the trench, according to the McCracken Co.

Due to the low water content of the mix, the thorough packing and the careful curing methods followed, the resultant concrete has a crushing strength in excess of 4,000 lb. per sq. in., an absorption of less than 8 per cent, and resistance against 15 lb. hydrostatic pressure, the manufacturer states.

There was a time when electrical engineers had some doubt about the suitability of concrete as conduit material, due to the corrosive action of free lime upon lead sheathed cables. The Commonwealth Edison Co., Chicago, has been using concrete conduits exclusively for more than 15 years and finds that factory-made concrete conduits, properly cured, result in no corrosion of cables whatever. They have installed over 20,000,000 ft. of single duct concrete conduit made on a McCracken machine of earlier design and are installing more at the rate of two or three million feet a year. N. E. Buck, superintendent of underground cable work for the company, says he has pulled over a million feet of lead cable that had been in the McCracken concrete conduits for ten years or more without finding a single case of lead sheath corrosion.



New Equipment and Materials

Viber Electric Tamper Inserted into Concrete

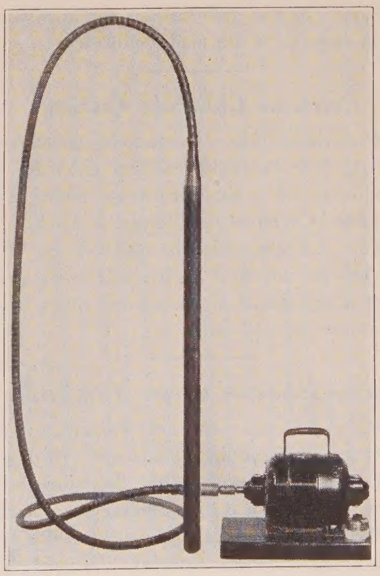
The Viber Co., Los Angeles, Calif., announces the manufacture of a new type of unit known as the Viber electric tamper.

The standard size Viber compactor consists of a 1¾-in. tube, 36 in. long, in which a shaft carrying an eccentric weight is caused to rotate by a ⅓-h.p. electric motor. The mechanism is so arranged that the motor causes the tube to vibrate at a rate of 5,000 vibrations per minute.

In operation the tube is inserted into the concrete, supplying perfect compaction in from 30 to 45 seconds, according to the maker.

For placing concrete in walls, the tamper is supplied with a flexible shaft which permits proper placing at any desired depth up to 20 ft.

With concrete of ordinary consistency,



vibrations are said to be plainly noticeable ten to twelve feet from point of application.

Best results are obtained when the concrete is placed in layers about the length of the vibrator. Actual operation experience is said to have shown that one Viber electric tamper will do the work of from 5 to 15 hand tampers.

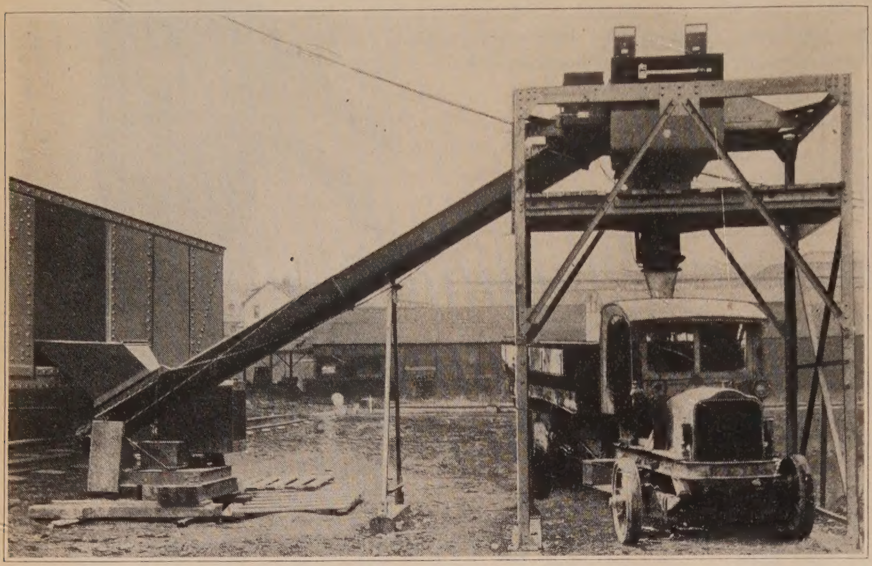
The Viber electric tamper will operate on any 110-volt current. A 25-ft. cord is supplied as standard equipment.

Low Cost Bulk Cement Plant Requires No Bin

A low cost, "handy" bulk cement plant for road contractors is a new product of the Blaw-Knox Co., Pittsburgh, Pa.

The hinged car hopper is adjustable to car height for the use of buggies or scoop shovels, no bins being required. A 4-cyl. engine operates the enclosed screw conveyor which loads a 1,000-lb. double beam cement weighing batcher.

A canvas chute controls the discharge into truck compartments. The entire plant is said to be easily portable.



Medusa Announces Floor Coating for Hard Wear

A floor coating recently announced by the Medusa Products Co., a Medusa Portland Cement Co. subsidiary, Cleveland, Ohio, is said to contain a special pigment which is three times harder than steel and insures resistance against normal abrasion and wear on concrete and wood floors.

It is economical, according to the manufacturer, who states that only one coat is required over previously painted surfaces or over Medusa Primer.

The paint is manufactured in the following colors: Light gray, dark gray, tile red, brown and black.

About Makers of Equipment and Materials

Industrial Literature

Preformed Wire Rope

The American Cable Co., New York City, has just issued a booklet entitled *The Cardinal Reasons Why Tru-Lay Saves Money*. Twelve reasons for the service said to be given by Tru-Lay preformed wire rope are presented in detail.

Copies of the publication are available upon request to the manufacturer.

Calcium Chloride Curing

The simplifying of concrete pavement curing with Dowflake calcium chloride is the theme of a new broadside issued by the *Dow Chemical Co.*, Midland, Mich.

The calcium chloride method is described as the most easily controlled and automatic method of curing and other features are pointed out.

Micro-Asbestos as an Admixture

Micro-Asbestos As An Admixture in Concrete in Building Construction (Mikro-Asbest als Werkstoff in der Bauindustrie) is the title of an 8-page illustrated reprint in the German language issued by Heinrich Rosenberg, of the firm of *Bernfeld & Rosenberg*, Wahringerstrasse 33, Vienna, Austria.

Bernfeld and Rosenberg handle this admixture in Europe. In the United States and Canada it is marketed under the names of asbestos floats, or asbestos waste.

Manufacturers' News

Wisconsin Sales Office

Since April 1 all business in Wisconsin territory of the *Huron Portland Cement Co.* is directly under the control of the Detroit general offices. A district sales office is maintained at Milwaukee, however, to which orders may be directed.

Barber-Greene Pittsburgh Representative

The Barber-Greene Company, Aurora, Ill., manufacturers of standardized material handling machinery, announce the appointment of *D. B. Frisbie*, veteran Barber-Greene salesman, as new branch manager of their Pittsburgh office.

Mr. Frisbie has been with the company since 1918, and was the first salesman taken on after the company organized. He opened the first Barber-Greene branch office, in Cleveland, Ohio. In his long service he has been eastern sales manager with office in New York, southern sales manager with office in Atlanta, and field sales manager, working from Aurora.

Lackawanna Sheet Piling

Lackawanna steel sheet piling, manufactured for many years by *Bethlehem Steel Co.*, will in future be designated as *Bethlehem (Lackawanna) steel sheet piling.*

Effective May 1st, the sale of this product is being handled by *Kalman Steel Corp., a subsidiary of Bethlehem Steel Corp.*

The Kalman Steel Corp. will also engage in the repurchase and resale of used steel sheet piling.

The Pacific Coast Steel Corp. will handle this product in a like manner on the Pacific Coast.

Cellastone Aggregate

Cellastone light-weight aggregate manufactured from blast-furnace slag, is to be produced by the newly formed *General Aggregate Corp.*, St. Louis, Mo. A $150,000 crushing and screening plant will be established, probably at Granite City, Ill.

The company is headed by *Claude H. Hunsaker*, resident manager of the Massey Concrete Products Corp., *Bert Boaz*, and *H. E. Billman.*